SCIENCE AND GOD

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LONDON

G. BELL & SONS, LTD

1933

Printed in Great Britain by The Camelot Press Limited
London and Southampton

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INTRODUCTION AND PREFACE

THE following pages contain the substance of a series of lectures given by the author in a number of German towns (Mainz, Cassel, Münster, Bremen, Minden, Dortmund, Düsseldorf, Bochum, Barmen, Mannheim, Saarbrücken, Neunkirchen, Hamburg, Neumünster, Krefeld, etc.), before scientific societies and similar bodies, and also before theological congresses, associations, and religious societies. The lectures aroused great interest in practically every case, especially in scientific circles. This I took as a proof that a large number of people to-day are conscious of the fact that we are at a turning point in the history of human thought; a point comparable in importance only to that period, 300 years ago, when great men of science, Galileo, Copernicus, Kepler, Newton, and others, created a new view of the world for European mankind.

The new knowledge which threatens to-day to undermine the 'classical' world-picture, is, it is true, still in the full tide of its development, and hence a certain amount of doubt may be felt, especially by the more fully informed scientist,

as to whether it is legitimate already to bring before the general public ideas still in a state of flux, and to discuss their bearing upon the philosophy of life. It is, however, impossible to prevent such discussion taking place ; science is to-day common property, at least as regards the educated classes, and if its professional representatives refuse to place their fundamental and important results before the public, the inevitable result will be that a 'scientific back-stairs literature' (to use an expression of Bastian Schmidt's) will take charge of the situation, and very possibly put the matter in a distorted and tendentious form. It was for this reason that I regarded it as my duty to appeal to a wide public with my lectures, and now do so with this little book.

If I am obliged to simplify the scientific groundwork here and there, in order to render it intelligible to the lay public, I must beg those more fully initiated to excuse me on this ground of popular appeal. The matter, even then, remains difficult enough, and I must therefore beg those readers who do not feel satisfied with the reasons given, to become more fully acquainted with the physical evidence. For this purpose I would refer them to my work *The Anatomy of Modern Science.*

In the present work I am only concerned to sketch in outline the new view of the world which appears to arise out of the revolution in modern

physics. Hence it is addressed, in the first instance, not so much to scientists as to thinkers of all categories, but particularly to theologians and philosophers. Its object is to insist upon the fundamental change which has taken place in all the assumptions upon which philosophical and religious discussion are based. If, as I hope, many scientists will also read it, I beg them not to be irritated if I seem, at certain points, to lose myself in pure theology. And I also beg the non-scientific not to despair if I offer them many a hard nut to crack from modern physics.

No one can understand the present position of affairs without being at some considerable pains to follow, at least in a general way, the new results of science. Hence this book is not light reading, at any rate for the non-scientific. But anyone who takes the trouble to go into matters a little more deeply will agree with me when I say that our grand-children and great-grand-children will envy us for having lived in such a time of intellectual change, and that it is therefore worth while for us to be conscious of the fact.

I

THE WORLD-PICTURE OF CLASSICAL MECHANICS

MODERN science, as every educated person knows, arose out of the great discoveries and theoretical developments made, mainly in the 17th century, by a number of distinguished men, Galileo, Kepler, and Newton being the names best known. We know that all of them were men of great piety, who had no intention of arousing opposition to traditional Christianity. On the contrary, they all three were convinced that their investigations were nothing other than the discovery of God's works and a tribute to His glory. Kepler stated this quite clearly at the close of his great work on the *Celestial Harmonies*, but Galileo and Newton also said the same thing in their own words. None of the three dreamed, or could dream, that their discoveries would end in an intellectual movement which would turn European culture, during a period of three hundred years, increasingly away from faith in God, and from all that goes with such faith ; and that finally this movement would end in simple and

unconcealed atheism and materialism, which is to-day the official philosophy of Bolshevist Russia. In order to understand the present position, we must consider somewhat more in detail how this state of affairs came about.

Science owes to Galileo, first of all, the foundation of the 'method of induction'; that is to say the principle, now regarded as self-evident, that all general knowledge in physical science can only be derived from carefully worked out experiments, or careful observation of natural phenomena taking place without our intervention, as in astronomy, meteorology, etc. When Galileo for the first time allowed balls to run down inclined grooves, and counted the swings of his pendulums, modern science, in the true sense of the word, was born. For although in earlier times thought had started of necessity from known experience (without which no beginning is possible) all endeavour, since ancient times, had nevertheless been directed towards banishing from 'science,' at the earliest possible moment, this empirical element, as being unworthy of the higher thought; since Plato's time, the development of geometry has served as a typical example of such purely mental science. Galileo's greatest achievement was his proof of the fact that science cannot advance in this way, but only by continually resubmitting its results to the test of experience.

Furthermore, he himself propounded the chief fundamental concepts of physics, particularly of mechanics, and discovered the fundamental laws, including the law of inertia, which is the foundation of mechanics. It was upon the foundations laid by him that Newton, about 50 years later, erected the first structure of theoretical physics.

The most important application of the general principles thus discovered was the explanation of the planetary motions, the actual laws of which were known through the immortal work of Johannes Kepler. Newton recognised that the three 'Keplerian Laws' can be derived as consequences of the law of gravitation: 'all bodies attract one another mutually with a force which is proportional to the product of the masses of the two bodies, and inversely proportional to the distance between them.' He further recognised that terrestrial gravitation is nothing but a case of this same law, in that every body on this earth is attracted by it in accordance with the law. He also deduced from it correctly the laws of the tides in their main outlines, and predicted that the planets, in accordance with his law, would slightly disturb one anothers' motions, the elliptical form of their orbits thus being only approximate. Confirmation of this prediction soon followed.

Newton's achievement was of such magnitude, that he was soon regarded by his contemporaries

as the supreme authority, and his work *Philosophiae Naturalis Principia Mathematica*[1] very soon occupied a similar position to that held by Euclid's *Elements of Geometry* since Classical times.

It seemed likely that, along with the fundamentals of Newtonian mechanics and astronomy, those of all other possible physical phenomena would sooner or later be rendered comprehensible, and so we find that, not long after Newton's time, the whole of philosophy was dominated by this world-picture, which we call to-day that of classical mechanics.

What are its chief characteristics? We find them most clearly expressed in Kant's *Critique of Pure Reason*, which, for the most part, is nothing more than the application of Newtonian mechanics to the theory of human knowledge. The following are the chief points to which we must pay attention.

Firstly: space and time form in Newton's (and hence Kant's) system the empty forms of all physical events. Themselves devoid of all further qualitative characteristics, they nevertheless contain in themselves the possibility of all physical happening whatever. In other words, what can be stated physically, can always be put in terms of the location of things in space and time. Or

[1] 'The Mathematical Principles of Natural Philosophy'; generally referred to as 'Newton's *Principia*.'

to put it quite crudely: physics consists of nothing but spatial and temporal change, i.e. motion.

Secondly: it is necessary to specify what it is that executes these motions (i.e. changes of position with time). This something is defined by Newton by the concept 'quantitas materiae' (quantity of matter), or as we now say, mass. The characteristic property of matter is inertia, or momentum, on the one hand; on the other, the power of moving masses to transfer their impetus to other masses. The question whether the natural measure of this impetus is the product of mass and velocity, or mass and square of velocity, led to a long polemic between the disciples of Descartes and Leibniz. Later physics makes use of both products, calling the first (product of mass and velocity, $m\,v$) impulse or momentum, and the second (or more accurately, one half the pruduct of mass and square of velocity, $\frac{1}{2}\,m\,v^2$) kinetic energy.

The third peculiarity of all material masses, as stated by Newtonian mechanics, is gravitation.

As philosophically regarded by Kant, this notion of mass is nothing more than the old philosophical concept of *substance* transformed into a precise physical concept, and Kant therefore identifies the 'law of conservation of substance,' already a commonplace of ancient philosophy, with the physical law of conservation of mass.

All this has subsequently become so familiar, that most people have much greater difficulty in criticising these notions, than in accepting them.

Thirdly: the various bodies, or mass particles of the universe, exert, according to Newton, certain *forces* upon one another, forces of which gravitation is perhaps only a special case. The effects of all possible forces may, like those of gravitation, be formulated by certain equations (laws of force). When we know these we are able, just as in the case of the planetary motions, to calculate the behaviour of a given physical system with perfect exactness both forwards into the future and backwards into the past, when once we know the exact state of the system at a given instant of time.

The astronomer, for example, must know for this purpose the exact position (co-ordinates) at a given instant, of every body (for example, of the planetary system) and its mass and velocity at that instant (taken together, mass and velocity are impulse). From these 'initial conditions' he is able, as we know, to calculate solar and lunar eclipses, and so on, accurately to a second; and not only for the future, but for the past as well, a matter of importance as regards historical research.

According to the classical mechanistic conception of the world, exactly the same thing should be

possible for every kind of physical system, if only we succeed in discovering the exact positions and impulses of every mass-point in the system at one given moment, and know also the laws of force according to which the various parts of the system act upon one another.

In Kant's theory of knowledge, the physical concept of force appears as the 'category' of *causality*, which according to him represents, like the category of substance, a form of thought projected into nature by the mind which knows. Hence we find in Kant a corresponding 'law of the conservation of force,' which is the philosophical forerunner of the law of the conservation of energy.

To summarise what has just been said: *the world consists according to the mechanistic picture given by classical mechanics, of an enormous number of single mass-points which act upon one another according to certain laws which remain to be determined. If we know, on the one hand these laws, on the other the exact state of the system at any one given moment, that is, the position and momentary velocities (impulses) of all mass-points, the whole past and future of the system in question, and in the limiting case of the whole universe, can be calculated with mathematical exactitude.*

Hence if we imagine a mind possessing both this knowledge and the necessary mathematical aptitude (Laplace's World Spirit), it would be able to

calculate the whole past and future history of the universe, if given a single 'world-section.' This fiction, invented by Laplace, gives us the essence of the world-picture in question. As we know, it played an important part in the discussions which took place at the end of the 19th century concerning the 'limits of natural knowledge,' after the Berlin physiologist Emil Dubois-Reymond had given an important address to the Naturforscherversammlung in 1872. This address, and its later repetition under the title *The Seven Riddles of the Universe* (1880), also formed the basis of Haeckel's *Riddle of the Universe.*[1]

Before we turn to philosophical and religious questions, there is one further point which we must mention. The classical mechanistic world-picture contains a fourth assumption which Kant likewise recognised, and formulated quite clearly in his *Critique*, also holding it to be an *a priori* constituent of all scientific investigation, that is, to arise out of our forms of perception and thought. This assumption is that of the *continuity in space and time of all natural events.* Another philosophical principle of great antiquity, 'natura non facit saltus' (nature does not make leaps), thus acquires the more precise form that all changes, or in the

[1] The English reader may be reminded of Tyndall's famous British Association address, in which he spoke of the 'fortuitous concourse of atoms.'

terms of the world-view under consideration, all motions, represent a series of states which succeed one another uninterruptedly and continuously; that is to say, every intermediate value between the initial and final values of a physical magnitude occurs at least once.

When, in the simplest case, a mass-point moves along a straight line from a point A to a point B, it is to be found at every instant of time during its motion at some quite definite point between A and B; and conversely, it reaches every point along the line at a quite definite instant of time. Leaps, that is, discontinuous motions, do not occur. When changes occur which appear to represent discontinuous states, we assume that our powers of observation are not sharp enough.

In other words: every process, no matter how apparently momentary (as for example, a flash of lightning), really occupies a certain time, however small; and this time is again to be thought of as filled up with a continuous succession of states, of which we see only the initial and final, since they take place too quickly for our powers of observation. In innumerable cases, investigation based upon this principle has finally also succeeded in grasping the intermediate states. Thus for example, the actual course of an electrical discharge can now be followed completely on rapidly moving photographic films; quite recently

important progress has been made in this particular respect.

The technical question does not interest us here; we are only concerned with the fundamental fact, *the assumption of the continuity of all natural processes*. For this reason, the branch of mathematics dealing with such continuous changes, the differential and integral calculus, has become the method most closely adapted to physics; indeed, this mathematical method had to be invented (by Newton and Leibniz) before modern physics could come into existence.

This fact is of importance because, as we shall see later, it is just this assumption of the classical world-picture which has been very seriously shaken by the most recent development of physics. It appears to us to-day quite conceivable, indeed probable, that the world has a fundamental resemblance to a cinematograph. In the latter, the succession of pictures is really discontinuous (about 24 per second), but our eyes weld them into a continuous impression. A modern physicist, Planck, once remarked that, while it appeared self-evident to the ancients that nature makes no leaps, we of to-day must ask ourselves in all seriousness whether she ever does anything else! We shall return to this point later.

The mechanistic picture of the world ruled physics until about the end of last century, and

even to-day a few supporters of it are still to be found among both physicists and philosophical theorists on the nature of knowledge; these hold the view that any other picture is fundamentally impossible. In the case of physicists, the reason is no doubt to be found in the fact that this world-picture is nearest to 'common sense.' The phenomena of motion which form the subject of mechanics are just those phenomena most familiar to us in our daily experience; the feeling of force which, regarded psychologically and historically, forms the basis of the concept of physical force, is an experience directly known to everyone, and the inertia of matter is familiar to the smallest child to its cost, when it knocks itself against a table or other large object.

We may therefore say that in the mechanistic world-picture, only the most primitive elements of experience, known to every human being, are made use of in forming the fundamental concepts; and hence it is difficult for very many people, even trained scientists, to see that these concepts must not be put forward without closer investigation as the only possible basis for physics. After all, other direct elements of experience exist, for example the sense of heat or light, which, at any rate at first sight, cannot be immediately reduced to mechanical terms. Hence it is at least necessary to wait and see whether this can be done, before

categorically asserting that all physics can be reduced to mechanics.

At first, it is true, the physicist's attempts at mechanical explanation of non-living nature seem to have gained a series of important successes, and we can therefore understand how the opinion became a dogma, that the final goal would be attained in not too long a time. It is evident that acoustics, the science of sound, can be reduced to the simple application of mechanics, for it deals only with phenomena of oscillation and wave motion, that is to say, motions of matter. Hence it at once suggests that what is true in its case may very well be true in other fields where our direct experience is peculiar and non-mechanical in quality; for sound, of course, appears to us to be something altogether different from motion. If physics did not tell us, we should not readily arrive at the notion that the sound of the A string of a violin is actually the result of a periodical pressure upon the ear drum, repeated 435 times per second. If this is the truth about a sound, why might not something similar be true of a colour or a sensation of heat?

And in actual fact, physics appeared to succeed in resolving both these fields of knowledge, optics and acoustics, into mechanics. We will here omit the detailed history of the theory of light. Let it suffice to say that, early in the last century (1820),

Fresnel's wave theory of light seemed to reduce it also to a wave motion: not, however, a wave transmitted by the ponderable substance known to us as matter, but by a substance of quite another kind, the existence of which it was necessary to assume for the purpose, and called the 'luminiferous ether.' This ether was supposed to have many extraordinary physical properties. On the one hand, it exceeded the hardest steel in elasticity since the velocity of propagation of the elastic waves in it, supposed to constitute light, is enormous, and hence argues an enormous modulus of elasticity. On the other hand, it had need to be so tenuous, that the planets could move through it without encountering the least resistance. These notions were difficult to reconcile with one another, and the attempt would not have been made but for the great success of the Fresnel theory.

A second and still greater success of the mechanistic view was the reduction, in the second half of the last century, of the science of heat and its laws to mechanics by means of the *kinetic theory of heat.*[1] According to this, heat is nothing but the energy of motion of the single mass particles (molecules) of bodies. Higher temperature means a more rapid motion of them, conduction of heat is transference of energy from one set of molecules to

[1] Cf. Tyndall's famous book, *Heat as a Mode of Motion.*

another. This theory has not only been confirmed in every way; it is only quite recently that we have been able to prove with absolute certainty that it is true. It is impossible to entertain the slightest doubt that the physical state revealed to us by the nerves of our skin as a feeling of warmth, is the energy of motion of the molecules of a body. In this case, therefore, the mechanistic world-picture is perfectly correct.

But alongside mechanics, acoustics, optics, and heat, we have, and have had since the end of the 18th century (or longer, for Gilbert worked in 1600), a further branch of science, electricity and magnetism, which defied all attempts at mechanisation, in spite of the enormous labour devoted to this end. At first, this stumbling block in the path of mechanisation was not taken very seriously, for an exact knowledge of the laws of electricity and magnetism has only been acquired more recently. This again is due to the fact that we are without a special sense for electric and magnetic phenomena, such as we have in the case of sound, light, and heat, and hence are obliged to construct all our means of observation, such as electrometers, galvanometers, etc., artificially.

However, as soon as this field came to be fully cultivated, in the first half of last century, it became increasingly clearer that in it we are dealing with phenomena which can never

conceivably be referred to mechanics. On the contrary, the development of electromagnetic theory very soon led to the science of optics being transferred to its domain, and removed from that of mechanics, in which it had seemed to belong; and finally, mechanics itself began to be absorbed into electromagnetics. We shall have to deal more fully with these developments later, but will first glance at the effect of mechanistic physics upon the world-view of Europe.

II

THE WORLD-PICTURE OF MECHANISTIC PHYSICS

THE revolution in European thought brought about by the development of modern physical science has often been described, and we need not here describe it again at length. We must be content to draw attention to a few of the essential points, those having most relevance to the present position. In particular, we will leave aside the changes in our view of the universe caused by the discovery of its enormous extension in space (Galileo, Bruno, etc.), although this fact certainly planted in innumerable minds the first seeds of doubt concerning traditional cosmogony.

The three points relevant to the present discussion are as follows: firstly, modern science has greatly influenced our idea of God; secondly, it has changed essentially our notions of the relationship between mind and matter, body and soul; and thirdly, it has led us to see the part played by mankind, and by human civilisation, in the economy of nature, in a totally different light from

that of pre-scientific generations. We will now consider these points more closely.

A consideration of the history and origin of religion is beyond our present limits. All in all, as I see it, we can distinguish three main directions of religious thought and feeling, which may be characterised by the terms nature-worship, ethics, and redemptionism.

On the first level the gods (also demons, spirits, mana, etc.) are chiefly powers which, by analogy with the activities of man, are regarded as beings active in nature, whose favour is to be gained, and wrath averted, by means of religious practices. On the second level, which of course cannot be sharply separated from the first, the gods are, either in addition or even solely, the guarantors of the validity of moral laws, which are, of course, present in some form even among the most primitive peoples. Finally, on the third level, we have transcendental godhead, in which man takes refuge from the stress and internal strife of this world, and also of his own soul. It is also obvious that this stage includes the other two, since only a person governed by some moral purpose can attain redemption, and equally so that the God or gods which guarantee this redemption must be the rulers of nature, since otherwise they could not save mankind from it. It is easy to give examples of these three types from the history of religion.

But even on this purely religious basis, certain conflicts arise between one set of ideas and another. It is clear that ethical religion, and still more redemptionism, tend to a monotheistic conclusion, as the history of religion proves. The same direction is taken, at least among certain peoples, by philosophical thought, as it gradually separates itself from religion. On the other hand, as long as no science in the modern sense existed, full force was retained by all those impressions which again and again led primitive man to an anthropomorphic interpretation of natural processes, that is to say, to the assumption of powers (gods, etc.) at once super-human, and human-like. It is well known that such notions continue to influence even the highly developed religions, including Christianity itself.

The prophetic spirit in Israel was obliged continually to strive against the relics of nature cults, and Christianity was only able to displace the nature-gods enshrined in the hearts of our distant ancestors, partly by transforming them into Christian saints and the like, and partly by 'satanising' them, although the logical development of monotheism naturally required that they should simply be denounced as non-existent creatures of the imagination.

During the whole of the Middle Ages, alchemy and astrology were studied with ever increasing

assiduity, and belief in witchcraft and magic was almost universal; in other words, along with monotheism there existed a mass of mythological and demonistic notions, to which we need do no more than refer in this place. But even in circles completely or almost completely emancipated from these relics of superseded religious ideas, the view held regarding the relationship between God and the world was nevertheless not far removed from the earlier mythology. Even for Kepler, the laws of the heavenly bodies were the direct outcome of the Creator's wisdom. The well-known closing sentence of his *Harmonices Mundi* is a proof of this, as are also his indefatigable attempts to read Divine wisdom directly into the laws of cosmic structure, particularly that of the solar system, in accordance with the Platonic regular figures, etc.

No one in those times entertained the notion that there are 'laws' without a lawgiver, a logically comprehensible order without a mind that created it. The 'law of nature,' in this sense completely neutral, the meaning of which goes no farther than the expression of a simple order, taken note of as such, like any other earthly fact: this notion, so familiar to us to-day, did not arise until the time of Galileo, Newton, Laplace, and their contemporaries.

Thenceforward, every kind of 'anthropomorphic

short-cut' was rendered fundamentally impossible. Soulless and Godless nature ceased to be the 'living garment of Deity'; this manner of thought fell to the rank of a metaphor. Instead, the adequate picture of nature became the machine, the mechanism moving according to fixed and calculable laws, instead of the organism in perpetual flux, never to be comprehended completely, moved by an inward spirit. It is at once obvious, that in this way the *theistic* conception of God necessarily became changed to the *deistic*; accordingly, we find the latter conception gaining a complete victory during the period of 'enlightenment.' It is also clear that this development could not cease at this point, but had to continue to atheism. For what real interest could there be for us in the notion of a God who was no more than the constructor and winder of the cosmic clock, which He then left to run down mechanically? Such a God might impress the theorist, but had no meaning for faith.

But here a second question arises. The elimination of God from nature means also the elimination of soul. And this of necessity presents us at once with the completely insoluble problem of how such a dead mass of machinery can come to possess sensation and will, which nevertheless exist beyond a doubt – indeed, more certainly than anything else, since we are directly aware

of them in ourselves. Everyone acquainted with the history of philosophy knows how this problem has puzzled philosophers since Descartes, who was the first to point out clearly the unbridgeable difference between the *res extensa* and the *res cogitans*. And to-day, the problem of body and soul (or mind and matter) remains altogether the most indigestible of all our philosophic problems.

Democritus certainly taught, in antiquity, an atomistic materialism. But this doctrine was unable to prevail either then, or in mediaeval times. The success of mechanistic physics after Newton was necessary to give it a substantial foundation. Only on such a foundation could books such as de la Mettries' *L'Homme machine*, or Büchner's *Kraft und Stoff*, come into existence. In them, all psychical phenomena are consistently regarded as simply peculiar accompaniments of material, that is mechanical or physico-chemical, phenomena. Quite recently we have seen a new edition of this materialism in the form of American Behaviorism, although in this case the principle is somewhat more concealed, and is presented rather as a method of investigation than a metaphysical doctrine.

But for all those who perceived, as a result of more profound consideration of the question, that such materialistic metaphysics was untenable,

since by no means at all can the psychical be deduced from the material, the problem remained hopeless. Dubois-Reymond, in his well-known address, stated this point in the clearest terms: we can conceive no reason why a mass of moving atoms or the like should be anything but completely indifferent, for all eternity, to its own fate. Since those days, it has been customary in Christian circles to state this dualism, which has been extended by the doctrine of psycho-physical interaction, that is to say, the mutual influence upon one another of mind and matter or body. Scientists, on the other hand, adhered to psycho-physical parallelism, while philosophers mainly inclined to the theory of Identity, or the 'doctrine of the unknown third.'

But all these solutions of the problem were, and remained, programmes, and not real solutions. And the direct opposite of materialism, spiritualism,[1] the doctrine, that is, that the spiritual alone is real, seemed to hold out even less prospect of success. The 'rigid lumps of reality' given by the scientific doctrine of atoms, barred its path. How are we to imagine, from a purely psychical or mental or spiritual point of view, the behaviour towards one another of these atoms, or their construction out of still simpler elements? Here

[1] Not, of course, in the 'spook' sense; in England this view is associated chiefly with Bishop Berkeley's 'idealism.'

nothing but the laborious and purely empirical methods of chemistry and physics are available.

Even worse than this complete helplessness in face of the psycho-physical problem was the fact that, at this point, the rôle of spirit in science seemed to be completely played out. Since the transformations of matter appeared to be capable of complete comprehension and calculation, the opinion gained ground more and more that scientific knowledge could only be advanced by referring phenomena to the laws of matter, that is, to physics and chemistry. And although biology at first appeared likely to resist this programme successfully, so much so that Kant could express a doubt whether a 'Newton of the blade of grass' would ever appear, nevertheless, numbers of people regarded Darwin as this Newton of biology, and after his time, mechanistic views gained almost sole possession of the biological field. It is, by the way, characteristic of Kant's position that he looked for the appearance of such a figure in biology, and regarded mathematical physics as the only perfect science.

It is only in recent times that some modification of this position has taken place; attention has again been directed to the mass of problems which remain completely unsolved. Nevertheless, the prejudice in favour of mechanism remains so strong that even declared vitalists, such as Driesch,

who are opponents of the mechanistic view, so far agree with the latter that they would have us attempt to understand the behaviour of living creatures, particularly animals, by a purely behaviouristic method, since they suppose that only such a method can lead to real knowledge. This programme has been strongly urged by modern positivism (Carnap).

Finally, the third and last problem of our world-view is the relation of man as a spiritual being to nature; that is, the problems of the ego and freedom of the will, and those problems very closely connected therewith, namely the meaning and nature of values – the True, the Good, the Beautiful, etc. We are still living to-day in the midst of the great process of dissolution which has overtaken the faith in the absoluteness and independence of all these values. If nature be a calculable machine, man, who after all is only a part of nature, appears to be like every other creature, simply a product of it, not its creator. In the last event, therefore, it is not he who has made history, but history that has made him what he is. The same is true of the individual life. If Laplace's World Spirit is really in a position to calculate the whole history of the universe both forwards and backwards by means of its equations, then the part played by me, a tiny wheel in the great clock, here and now and then and there, is

completely determined beforehand. The feeling of freedom which accompanies my actions is then simply a peculiar phenomenon difficult to explain, but of no essential importance. We know what a difficult struggle Kant's philosophy had with this problem, and finally, no resource remained to it but, as Schopenhauer once remarked, to readmit freedom of the will by the back door of 'practical reason,' after it had been politely shown out by the front door of theoretical reason. Kant's distinction between the 'intelligible' and the 'empirical' is a makeshift by means of which these contradictions are to be reconciled.

In actual fact, this solution has again only succeeded in convincing a few philosophers, but never a wider circle. Plain and simple thinking strikes again and again upon the hard but apparently inevitable consequence of mechanism: everything that happens is predetermined. What use have I for an 'intelligible' freedom? My sense of freedom, at any rate, has no knowledge of such a transcendental background; it relates entirely to this world of the senses. In this, I *believe* that I am able to act thus or thus. If this is an illusion, if I am in fact 'empirically' the slave of absolute causality, of what use to me is freedom in a totally different, metaphysical sense?

We will not here discuss whether such reasoning is justified or not, but simply state the fact that the

great majority of people will always submit to it, and that all 'Critiques of Practical Reason,' cannot, and never will be able to remedy this fact.

Along the path which we have just shortly indicated, atheism, materialism, fundamental relativism, and moral libertarianism have entered, as we all know, Western European culture in a broad stream, and penetrated so far that to-day we ask ourselves in all seriousness whether we are Christians at all; indeed, whether we still have any real religious life. And the effects of mechanistic thought are not even limited to this result. It has penetrated in other respects into almost all fields of our culture. The enormous success of science, and of technology founded upon it – and now that our critical faculties are awake, we must not forget how enormous this success is – has accustomed people to transfer these successful methods and concepts of thought to quite other fields. For example, as F. Tönnies and others have strikingly shown, we find, in almost all fields of human activity, the community (*Gemeinschaft*) replaced by the society (*Gesellschaft*); that is to say, the naturally grown, organic linkage together of human individuals (e.g. in the family, nation, etc.) replaced by the association formed for a purpose; the union, league, etc. This is a fundamental triumph of mechanistic habits of thought. 'Organisation' of this kind, which in truth is

always mechanisation, has nothing to do with an organism, but differs from it as water from fire. By means of it, it is hoped to attain some aim by making use of the resultant of many single forces: in short, the mode of thought is mechanistic, not organic.

It is altogether impossible to *make* an organism; it comes into being and grows according to its own immanent laws. At the most, we can assist or retard its growth. An organism is furthermore fundamentally different from a mere machine, inasmuch as the single wheels, levers, etc., of the latter are in themselves mere dead pieces of metal or wood, which possess no 'meaning,' no peculiar inward law of their own, but only when connected with the whole. It is true, of course, that the single cell of our bodies only exists permanently in connection with the whole, but is, nevertheless, an organic individual in its own right, indeed, as Carrel has shown, it is able to live by itself, and even multiply by division.

The total life of the organism is thus never a simple summation of the individual lives of the single cells composing it; it is an integration of a peculiar kind, for which no example exists in the physico-chemical world, with its simple play of forces. For in the latter, the whole is always the sum of its parts, whereas in the living world, it is always more than this.

Even the German nation, which perhaps more than any other was predestined to an organic view of nature and life, has lost, as regards wide circles, all feeling for the immanent laws of life, and has fallen a victim to a blind faith in 'organisation' as the only solution, whereas in reality everything is falling to pieces. This is perhaps the worst consequence of mechanistic thought, since the deluded masses are thereby prevented from returning to true insight. People stand before a corpse and debate as to the right means to re-awaken it by artificial galvanisation; or still better, since it was never much use when alive, to replace it by a cleverly constructed automaton. No one even imagines that only real life can awaken and transmit life.

The most terrible example of this error is Russian communism, which is nothing more than the horribly methodical application of the machine idea to human life as a whole. It also – and here it is a caricature of the organic point of view – knows the individual only as a member of a whole; but not in the sense set forth above, the participation of an individual life in that of a greater, more comprehensive unity, but in the sense of its pitiless and compulsive employment as a wheel in the works of the great economic machine. Here we have neither the individual life of the cell, nor a living whole; all is dead

mechanism. Hence it is not accidental, but a matter of inward necessity, that Lenin declared materialism and mechanism to be the official Soviet philosophy; that in Russia the teaching, and even the simple statement, of vitalistic views is punished with banishment or death; and that marriage and family life have been systematically destroyed. For here we actually have the final and logical carrying out of the mechanical principle in all departments of human life. Everything which has grown and developed naturally is simply sacrificed to this principle. Everything must first be stripped of all restraint, so that the rational dream-paradise may come into existence.

But the half-brother of Communism, Socialism in its Western European form – a kind of cross between communism and bourgeois liberalism – likewise stands fundamentally upon the same mechanistic foundation. It is necessary to emphasise this fact as against the widespread error, carefully nourished from various sides, that this socialism stands for the 'true organic community of the people.' For this purpose, it is usual to contrast it sharply with bourgeois liberalism, the supreme ideal of which was the individual 'personality'; and it is naturally undeniable, that very strong contrasts do exist between the two. Yet they have ultimately a common origin, and are two branches of the same tree, for

they are founded upon the same atomistic view of the world, in spite of the assertion by socialism of 'fraternity,' 'solidarity,' etc. The 'whole' towards which it strives – admittedly in contrast to liberalism – is finally only the whole of a machine or architectural plan; it is *made*, not *grown*. In order to be realised, it must first be put together out of the parts which are available, whereas a true organic whole always comes into being of itself. If any proof of this is needed, we have it in the undeniable fact that socialism, like bolshevism and also liberalism, has strikingly little understanding for the forms of life which have actually grown – the family, marriage, nation, etc. Like the other political creeds, it sees these only from the point of view of sociological forms which change and can be changed like everything else in the world; it is the idea of the *contrat social* by which we are all governed. But a contract can be altered as required, like every other rational construction.

For this reason, it is altogether misleading when this socialism, and even Russian communism, are lumped together with fascism and nationalism under the common term collectivism, this collectivism then being contrasted with the personality ideal of bourgeois liberalism. The fascist idea proceeds, in strict contrast to the socialist and liberal, not from a mechanistic, but

from an 'organismic' point of view. For it, the State of the future is not a theoretical construction, but the external form, aimed at if never attained, of a real life already present, the life of the nation. Hence it starts everywhere from what has grown or developed. When it demands compulsion and limitation of individual freedom, it does so, at least in principle, only when the will to live of the nation calls for it, just as the physician is obliged sometimes to cut out overgrown living body cells which are attempting to live an independent life of their own (cancer). But it is conscious that only cells themselves living can build up a living organism, and hence calls for the greatest possible measure of individual freedom, since only an independently developing individual life can serve as foundation for the all-embracing life of the whole. It is not here the question whether these principles are always adhered to, for instance in Italy. Our only object here is to make clear the inmost philosophical elements of these social and political movements. These elements are worlds apart in the case of the two 'collectivisms' so often confused by Liberals and Individualists. Hence it would be better to apply the word collectivism only to one category, namely the mechanically orientated; for a 'collection' does not mean an organic whole, but merely a number of parts or

individuals. The word is used in this sense in statistics, for example.

All this immediately points to the fundamental importance for our whole life, and not only our theoretical thought but our practical action, of the fact that the foundations of mechanistic thought in physics are to-day becoming insecure. This is a matter which is far from being solely the affair of the science of physics, or even of theoretical philosophy; it is bound to exert an influence, the extent of which cannot be foreseen, upon every department of human thought and action, from biology to paedagogics, from politics to religion, in which a fundamental change of thought cannot but take place, in exactly the same way as we know from history to have been the case with the mechanical world-view, which is now to be superseded. We can here only attempt to sketch a part of the new picture by means of a few provisional strokes; we shall deal chiefly with religion and philosophy.

But those who desire to arrive at clear views even in these fields, must obviously take the necessary pains to understand, at least in its general outlines, the new picture of the physical world which is in process of superseding the mechanical picture. It would be the greatest possible mistake to suppose that the results of modern investigation relieve us from all necessity

of paying attention to science, and allow us to return to the pre-Newtonian point of view. There is no going back; he who will climb the new ladder, must first have the old one below him. Hence we must first attempt to show the reader how quite shortly the old picture was gradually and in the course of years removed piecemeal, until finally, about five years ago, its final collapse took place.

III

THE DEMOLITION OF THE MECHANISTIC WORLD-PICTURE

WE are able to distinguish a number of more or less clearly defined stages in the process of demolition, though we must note that these were not in actual fact consecutive, but for the most part contemporaneous. The following may be taken as the chief stages: the final independence of electromagnetism, and its annexation of optics from mechanics; the recognition of a real existing something (the 'field') which has very few points in common with the matter of mechanics; the introduction of statistical methods alongside the old, strictly dynamical, laws of classical mechanics and electromagnetism; then the electrical theory of matter; and finally, the theory of relativity and the quantum theory. We shall have to deal with the latter in greater detail; the others must be dismissed as summarily as possible, in order to economise space.

The fundamental concept of present-day electric

and magnetic theory is the 'field,' not the 'charge' or 'pole.' The nature of a magnetic field is best made clear by the use of iron filings. It is a peculiar state of the space surrounding a magnet, which may be visualised directly by means of imaginary 'lines of force.' It is a fundamental error to explain this notion by a resort to mechanical points of view, such for example, as by analogy with a stretched sheet of rubber. There is no gain in clarity by referring to our experience with elastic bodies, for although we are able to 'feel directly' the tension in such an elastic body (we need only stretch a piece of 'elastic' for this purpose), the same is equally true of magnetic forces. Everyone who has ever played with a magnet and keeper has felt magnetic force directly. We must therefore realise quite clearly that concepts occurring in electromagnetism, such as 'field,' 'line of force,' etc., are fundamental concepts in their own right, which can equally well be regarded as the bases for explaining all kinds of other notions, such as the customary mechanical concepts.

But the electric and magnetic fields have the peculiar property of existing in empty space; indeed, only in it are they able to spread unhindered. Anyone who cannot get rid of the mechanical attitude of mind will repeatedly attempt to give this empty space a filling, so to

speak, with some substance, in which, or in connection with which, that state can exist which we call a field. The question of the exact nature of a field is not meaningless, but it is not necessary to answer it before we make further use of the field notion.

Let it suffice for the present that such fields exist, that they can change in time and space, that such changes are propagated in space with a definite velocity, 300,000 kilometres per second, which can be deduced from electromagnetic measurements, and that waves must also exist in these fields – electromagnetic waves, that is to say, periodic changes in the field values, propagated with the above-named velocity. The existence of such waves is familiar to everyone through broadcasting. Here also, unfortunately, simple and direct insight is repeatedly obscured by the superfluous resort to mechanical imagery. People talk of 'ether waves' and so forth, space being imagined as filled with a substance 'ether' invented for this purpose, which is then supposed to execute some kind of elastic vibration. This picture only hinders true understanding of the facts. *An electromagnetic wave is not a mechanical oscillation, but a periodic change in the field* (bear in mind the lines of force), which has only a formal resemblance to waves in the ordinary mechanical sense, inasmuch as the mathematical formulae

describing the propagation of the disturbances are similar in the two cases.

Anyone who fails to get clear about this point will never understand modern physics.

A further physical fact of fundamental importance is the identity of light with electromagnetic waves of this kind, and not, as Fresnel supposed, with mechanical waves. Waves of light only differ from broadcasting waves by reason of their much greater frequency of vibration or what amounts to the same thing, their much shorter wave-length. To render this clearer, we give here a short table covering the whole range of electric oscillations or waves known to us. The reader should carefully note that we are here referring only to electromagnetic waves, in the sense referred to above, and hence that sound waves, which are mechanical oscillations or ordinary matter, do not belong to this category, but are of an altogether different character. The question as to how sound can be conveyed by broadcasting cannot be dealt with here.

Frequency	*Wave-length*	*Nature and origin of Waves*
$10 - 10^5$ per sec.	30,000 – 3 km.	Alternating current dynamo
$10^5 - 10^{10}$	3 km. – 3 cm.	Broadcasting and 'short-wave'

Frequency	*Wave-length*	*Nature and origin of Waves*
$10^{10} - 1{\cdot}5 \times 10^{12}$	3 cm. – 0·2 mm.	Hertzian waves
$10^{12} - 4 \times 10^{14}$	760 – 380 $\mu\mu$	Visible light
$8 \times 10^{14} - 1{\cdot}5 \times 10^{16}$	380 – 20 $\mu\mu$	Ultraviolet
$10^{16} - 3\ 10^{20}$	30 – 0·001 $\mu\mu$	X-rays
up to $0{\cdot}5\ 10^{24}$	to 0·6 $\mu\mu\mu\mu$	'Penetrating' (often called 'cosmic') radiation

($1\ \mu = 0{\cdot}001$ mm.; $1\mu\mu = 0{\cdot}001\ \mu$; $1\ \mu\mu\mu\mu = 0{\cdot}000,001\mu\mu$.
In every wave motion, $c = \lambda\nu$)

Although electromagnetism was able to incorporate optics since Maxwell stated the electromagnetic theory of light in 1860, and thus remove it from mechanics, it was unsatisfactory to have physics divided into two departments, alongside one another, but entirely separated; and all the more so, since mechanical energy of motion could be transformed into electromagnetic energy, and *vice versa.* Such transformation takes place, for instance, in every incandescent body by the emission of light, for heat, which is the cause of this emission, is nothing but mechanical energy of molecular motion, while light undoubtedly consists of electromagnetic waves. The question thus arises whether, if light cannot be explained by means of mechanics, it may not be possible to carry out the reverse process, and base mechanics upon electromagnetism. This actually took place,

though the mechanical concept of substance was not reintroduced into electromagnetism. The fundamental facts concerning the electrical theory of matter, which was founded at the beginning of the century and developed later by the addition of the quantum theory, are somewhat as follows.

There are two kinds of elementary particles of matter, electrons and protons; the first are negatively charged, the second carry an equally strong positive charge. Both are contained in every normal material body in exactly equal proportions. An excess of electrons means a negative electric charge, a defect a positive electric charge. Both kinds of 'corpuscle' possess inertia and mass, but they differ greatly in this respect, the mass of the proton being about 1840 times that of the electron. The mass of the latter thus has hardly any effect on the total mass of the body. The compound of one proton with one electron, in which the latter revolves around the former like a planet around the sun, is a hydrogen atom. All the heavier atoms of the chemical elements likewise consist of a positive 'nucleus' and a number of electrons revolving around it. The nucleus itself does not consist of protons only, but of electrons as well; an excess of the former results in the 'nuclear charge.' All *chemical* processes leave this nucleus completely intact;

they take place only in the external regions of the electrons surrounding the nucleus.

But changes also take place in the nucleus itself; these constitute radioactivity and consist in the disruption of the nucleus, whereby one element changes of itself into another. The emission of light by incandescent matter takes place, according to this theory, by means of the revolution of the external electrons; its frequency is determined by the whole structure of the atom. This is the explanation of the facts of spectrum analysis; every element emits quite definite wave-lengths peculiar to itself, forming what is called its spectrum.

In addition to light radiation, we have another and entirely different kind of radiation – cathode rays, canal rays, and the α (alpha) and β (beta) rays emitted by radioactive bodies. These travel with a less velocity than that of light, and carry electric charges with them. Closer investigation shows them to consist of free electrons (cathode and β rays) and free atomic nuclei (α rays are helium nuclei), or whole atoms which have lost some of their external electrons, or acquired an excess of electrons (positive and negative ions). The investigation of these corpuscular rays has led to the conclusion that the inertia of these particles is not a fundamental property in the sense of classical mechanics, but a phenomenon which

can be deduced from the interaction between the electric charge and the surrounding field. The masses of proton and electron (about 1½ quadrillionths of a gramme, and 1/1840th of this respectively, denoted by M and m) are thus not primary qualities of this substance according to the theory, but pure phenomena, and not strictly constant. The values thus given are correct only for stationary or slowly moving corpuscles; in rapid motion their masses (inertias) increase, and would become infinite at the speed of light. It follows from this that it is impossible to cause a material body to move with this velocity.

It is naturally impossible for us, in this place, to go into all the complicated reasoning which has led to these conceptions of matter. They are fully valid to-day, and are likely to remain so.

Let us nevertheless consider for a moment its meaning from the philosophical standpoint already considered. For it is evident that protons and electrons are substance of the clearest character. Although their inertia is a secondary phenomenon, and hence renders invalid Kant's naïve identification of conservation of substance with conservation of mass or weight, these new elements of substance are fully subject to a law of conservation, for the theory assumes that they remain unchanged throughout all physical and

chemical processes, which consist only in regroupings and definite motions of these particles, accompanied of necessity by corresponding changes in the surrounding field.

The older concept of a corpuscle is modified, it is true, to some extent by the introduction of the field. We can say of an electron or proton with almost equal right that it is present in the whole of the surrounding space, as that it exists at any given point, since its field of force extends to infinity in every direction. But after all, this was also true regarding the gravitational field of the mass-points of classical mechanics.

We must further note that this electromagnetic view of things is just as deterministic as the older view. According to it also, if we know the present state of the world and the fundamental laws, in this case those of electromagnetism, we are able to calculate the whole past and future course of events. Hence the replacement of a mechanical world-picture by an electromagnetic world-picture hardly changes anything, though the crudely mechanical character of physics has disappeared.

In the above description of the atomic structure of matter, we have, it is true, largely anticipated historical development. The theories we have just given, mainly due to Bohr, were only formulated after the foundation of the relativity and quantum

theories, and make use of them to some extent. We must now go back about a decade to the year 1905, that of the foundation of Einstein's theory of relativity. This is not, of course, the place to give any kind of description of it. More than enough of this has been done in popular articles, without the theory having penetrated fundamentally into the popular consciousness. It is abstract and difficult to conceive clearly, and that is enough to set up an impassable barrier to its understanding for the majority even of educated people. But it is not a sufficient reason for those who do not understand it to hate it, for they do not feel the same emotion with regard to other theories which they would understand no better.

The reason for hostility to Einstein's theory obviously lies in the fact that it does not deal with remote objects, as do the other theories to which we have referred, but with matters with which everyone believes himself to be familiar by everyday experience. Hence it calls upon us to revise habits of thought which are near and dear to us, and such a demand usually causes a reaction of dislike in people, not only as regards physics and religion, but also in politics, art, etc. The more self-evident the old views appeared, the stronger the dislike excited by the new.

The theory of relativity was developed by Einstein in two stages. The so-called Special

Theory appeared first, the General Theory following ten years later. The two do not contradict one another, as we are sometimes told by foolish and ignorant persons; the later theory is an enlargement and completion of the earlier, which is included in it as a special case, namely, that of space free from matter. I may also say, for the benefit of readers not acquainted with physics, that the theory has not, as is sometimes stated, already been given up again by science. No such course is dreamed of; but most certainly it is hoped that means may be found to reconcile and unite it with other views concerning the nature of the material world, views which have sprung up upon other foundations.

Einstein himself, and numerous other physicists, are still working to this end; and recently both he and others have published attempts, all of which have proved insufficient, and hence had to be abandoned. A case of this kind recently led certain journals to publish the rumour that Einstein himself had abandoned the theory of relativity. What Einstein had retracted was one of his later attempts, to which we have just referred, to enlarge his theory; the problem dealt with was the incorporation of electromagnetism in the Einstein field theory, which deals in the first place with gravitation and inertia.

What is the meaning of the theory of relativity

for our world-view? Its philosophical consequences concern, as is generally known, our theory of knowledge. It means a blow, and in the author's opinion a death blow, to pure Kantian apriorism. But that does not greatly concern us here. The important part of this complex of problems is for us the fact that, in the first place, relativity has united space and time indissolubly (Minkowski); secondly, that it ties this 'space-time,' or in the language of the theory, world metrics, to matter, likewise indissolubly; and thirdly, that it teaches us to regard energy and mass (inertia) as fundamentally identical.

The first two points are definitely opposed to both the classical mechanistic, and the pure electromagnetic, conceptions of the world, and furthermore to the Kantian theory of knowledge. It means that order in space and time, that is, geometry and kinematics (theory of motion) no longer stand *a priori* to experience, with physical phenomena as tenants which have taken up their abode in this completely empty and quality-less order, as in an 'empty apartment house' (Weyl). This space-time order, or world metrics, is itself dependent upon the distribution of matter. It surrounds the latter in the same way as the magnetic field surrounds a magnet (indeed, according to a formally analogous law); in fact, it is a physical constituent of matter itself, so that

an 'empty universe' is just as meaningless a term as a citizen-less State, or a Church without adherents. The nature of the geometry and kinematics in my neighbourhood depends upon the distribution of matter around me; in the immediate neighbourhood of a great heavenly body such as the sun, geometry and kinematics are different from those at a distance.

This conception is at first one almost impossible for the layman to grasp. To it we must add a second important consequence of the theory, namely, the identification of matter with energy according to the equation $E=m\,c^2$ (where c is the velocity of light). This means that all energy possesses inertia (hence that both light and heat are 'heavy'), and conversely, that all mass (relativity identifies mass with weight) represents a store of energy. This consequence of the relativity theory is generally admitted even by its opponents; it is an accepted part of modern physics. If this notion be thoroughly thought out, we realise that it renders the whole concept of substance impossible. We shall return to this point at greater length, and therefore only refer to it here.

But in one essential respect the relativity theory agrees with the classical: it is strictly deterministic. It also supplies us with a system of exactly valid differential equations; indeed, we may say that

Einstein's object was to weld together the two systems of such equations which existed side by side in the older physics, namely those of mechanics and of electromagnetics, into a higher unity.

Hence, however great the revolution effected by the relativity theory in our customary ideas of space and time, substance and energy, in this one main respect it has effected no change at all. The world remains, for Laplace's World Spirit, calculable, as soon as the fundamental laws of which we have spoken, and which Einstein endeavoured to find, are known, together with a single 'section' of the world. In this respect it is a matter of indifference whether this world is euclidian or non-euclidian, whether substance be defined as mass-points, field strengths, or 'energy-impulse tensors.' However far removed we may be in other ways from the ideas of Newton and Kant, in this respect there is no change at all, as far as relativity is concerned.

Before we turn to the latest theories which have brought about a decisive change in our ideas regarding determinism, we need to say a few words concerning another development which prepared the way from another direction for the present transformation in our notions, and supplied ideas of fundamental importance for it. This is the third of the new developments referred to above: the invasion of 'exact' science, of

physics, by statistical methods and the theory of probability.

We saw above that the laws of heat can be referred to those of mechanics, if we assume that heat is nothing more than energy of motion of the molecules. But what do we mean by 'referred'? A cubic centimetre of gas contains, at ordinary pressures and temperatures, about 25 trillions of molecules (oxygen and nitrogen). Are we to understand that the physicist, in order to master the thermal behaviour of this cubic centimetre of gas, is obliged to calculate the paths and collisions with one another of these 25 trillions of molecules by means of Newtonian mechanics? If that were so, the whole of humanity might spend the whole of their lives calculating, without doing more than an insignificant fraction of the work required. Quite apart from this, it is obviously impossible to determine the 'initial state' for these 25 trillion molecules, that is to say, their positions and impulses at a quite definite instant of time, for we cannot hold the molecules still for an instant, or even take a snapshot of them, for they are much too small and numerous, and move far too quickly. In this case, it is true, we are able to postulate the Laplace ideal, but never to carry it out practically. Fortunately, we do not need to possess this special knowledge of the individual paths, and yet can arrive at useful results, for the

very reason that we are dealing with such an enormous number of individual molecules.

In all such cases we are sensible enough to make use of statistical methods, that is to say, to calculate with average values, instead of calculating exactly individual cases. If we calculate with an average velocity of all molecules instead of with the 25 trillion velocities, strictly speaking all different, we obtain the gas pressure, that is, the sum of all the blows given by these molecules to the walls of the vessel, with practically perfect accuracy, since every square centimetre receives blows from such enormous numbers of molecules, even in an excessively short space of time. Calculation gives in the present case about 200,000 trillion blows per second. We are thus able to reckon with a practically constant pressure, depending only upon the *average* force exerted by a single molecule. This branch of physics is therefore dealt with mathematically by means of the theory of probability, the purpose of which is to calculate such average results of a large number of single cases.

If I throw a die six times in succession, I cannot expect each one of the six numbers to turn up just once. But if I throw it 6,000 or 600,000 times, and it is truly made, and not heavier on one side, each number will come up with fair exactness in one-sixth of the total number of throws (i.e. 1,000

and 100,000 times respectively). Also, this fraction will be attained with greater exactness, the greater the number of throws (law of large numbers). This method, applied in the kinetic theory of heat, actually allows almost all the laws of the thermal behaviour of bodies to be explained.

Here we require to grasp clearly a fact of fundamental importance in our later discussion. The fact is this, that all laws thus derived bear from the outset a character entirely different from those exact laws of classical physics formulated by the differential equations of mechanics, electromagnetics, and Einsteinian relativity. The latter know no exceptions and no 'fluctuations'; they are simply binding, as far as their assumptions are applicable. The laws of heat, on the other hand, must in the nature of things, and because they are only statistical rules, exhibit exceptions, the more certainly, the fewer the number of molecules we are dealing with. If we consider a brick, say, and calculate the number of blows delivered by the air molecules upon the top and bottom sides of it, we shall find that, on account of the vast number of molecules acting, these blows will balance one another to practical perfection, even in the shortest possible space of time, so that the brick will not be moved by them. Perrin once calculated how long a bricklayer working on the third story would have to wait until, as

the result of a chance irregularity in the distribution of the molecular blows, a brick would jump up 'by itself' from the ground into his hand. He found that the bricklayer would have to wait on the average $10^{10^{10}}$ years. This is 1 with ten milliard noughts after it; if written, it would reach from the North Pole to the Equator. It is quite impossible for us to form any conception of such a number. So minute a probability is practically identical with absolute impossibility, and every builder will therefore arrange for bricks to be transported in the usual manner, rather than rely upon such a possibility. Only, we must understand quite clearly that it is a simple rule that we are dealing with here, and not a 'Law of Nature' in Laplace's sense.

This fact becomes clear the moment we reduce the number of molecules acting. If we take instead of the brick a tiny plate one-thousandth of a millimetre in diameter, and demand, not an impulse sufficient to carry it three stories high, but only that it shall experience, for a hundred-thousandth of a second a pressure difference of 20 per cent, this event becomes already so probable that we may see it happen under our eyes through a microscope. What is called the Brownian motion of minute particles suspended in liquids or gases, is nothing but the consequence of the unequal distribution of blows from

the liquid or gas molecules, which are in rapid motion on account of their temperature. We therefore see that the enormous improbability of an irregularity in the first example passes continuously into a greater and greater probability, and finally approximates to a certainty. It is merely a matter of the number of single cases (here blows from molecules) considered.

The applicability of statistical methods to physics goes much farther than appears likely at first sight. For on account of the molecular structure of matter, practically all laws which relate to processes taking place inside matter, as for example conduction of heat, transmission of sound, etc., can really only be properly grasped when they are treated as the sum of innumerable single molecular processes, which we are not able to perceive as such but only to treat theoretically but which nevertheless, taken together, produce what we see, hear, etc.

It is customary to-day to distinguish between the macroscopic and the microscopic or sub-microscopic mode of regarding phenomena. The simple seeming macroscopic laws, such for example as the law of heat conduction or the Boyle-Lussac law of gases, are thus in reality only the statistical rules of these phenomena, which can be studied without our knowing the individual processes and their possible causes. The statistical

method makes only one assumption: firstly that the number of single cases is sufficiently large, an assumption always fulfilled by the trillions and trillions of molecules always taking part in a macroscopic process. But the applicability of statistics requires another assumption which may be described as the exact opposite of order, and hence has been called the hypothesis of elementary disorder. The meaning of this is best understood in connection with the dice-throwing of which we spoke. If this is to give the expected result, namely, that the frequency with which any number is thrown approaches more closely to one sixth of the total number of throws, the more numerous the latter, we must be sure that none of the six sides is affected by any cause peculiar to it, such for example that it is heavier or rounder or what not. On the contrary, we should be quite correct in assuming the existence of such a special cause if we failed to get the expected result but got instead, say, the five more frequently than one in six of the throws. We are obliged to make similar assumptions concerning atoms and molecules.

The difficult philosophical problems which here arise, which all go back finally to the fundamental problem of all probability, the law of large numbers, cannot be dealt with here. The reader need only realise clearly, that the laws in

question assume elementary chaos. It is when the elementary processes are not ordered, and only then, that statistics gives us the summary laws under discussion, as the outcome of probability calculations. This naturally does not assert that the elementary processes cannot be subject to strict causality; but only that the statistical method makes no use of it. For instance, there is nothing in the theory of heat to prevent our regarding the path of every single gas molecule as strictly determined in the sense of Laplace's ideal, but the theory takes no interest in this single causality, it is satisfied with the quite general and purely superficial assumption of 'elementary disorder,' which means exactly the same thing as, in the case of the dice, the assumption that no side is distinguished from the others by any peculiar property.

It follows from these considerations, and from the historical development that, as Schrödinger once said, we may just as well deduce an apparent rule of law, by means of statistical rules, from pure chance, as assume strict causality in single cases as the foundation of statistics of this kind.

In other words, the existence of macroscopic 'laws' is in itself no proof of the assumption of an absolute determinism; these laws may only be statistical rules, the opposite of which is only immeasurably improbable, but not impossible.

On the other hand, no statistics of this kind can prove that in a single case, causality, postulated for other reasons, does not exist. They can only show that it is useless for their purpose. It is of great importance to bear this in mind in the course of the following pages.

And now we may turn to the new doctrines, which have led after all the above preparatory steps, to the complete collapse of the old physical picture.

IV

THE COLLAPSE OF THE MECHANISTIC WORLD-PICTURE

BEFORE we proceed to give a very short account of the new doctrines, we must make one remark by way of preface. We are taking a completely wrong view of the nature of the process of knowledge of physics, if we interpret the word 'collapse' in connection with the old ideas as a proof that physics intends to throw over its whole existing system and so replace its wisdom of yesterday by a new 'error of to-day.' Anyone who entertains such ideas has no conception of true natural science. In reality, the new ideas could only grow up upon the basis of the old, and have so grown up; and even to-day, no one can climb up into the higher regions now opened up, without first passing through the lower. In so far, nothing has been overthrown or has collapsed; what held previously, still holds to-day. For example, it is still true that the world of material bodies consists of 92 different sorts of atoms. The fact that these for their part consist of only two different primary particles

is a matter by itself, a further step which we have been able to take into the inward nature of things, and nothing more. Exactly the same is true of the laws of nature. The fact that they now appear as mere statistical rules does not in the least mean that they cease to be valid; but the word 'valid' has now acquired another sense, and hence a very different meaning as regards our general view of the world. Where the fundamental change has taken place is not in physics itself, but rather in its interpretation, in the wider frame of our notions of science and human intellectual activity – in short, in its philosophical interpretation. And this, again, is a fresh proof of the fact that in this field, namely the theory of knowledge, there are no such finally valid truths as apriorism of all shades imagined it possible to set up, but rather that our philosophical systems are themselves orientated with respect to the actually existing systems of science.

This destruction of the belief in an externally valid theory of knowledge, in the sense of Kant and his interpreters and successors is, in the first place, due to the theory of relativity. The geometric-kinematic systems upon which it is founded were simply not provided for by Kant, who knew only Euclidian geometry and Galilean kinematics, and anyone who attempts to reconcile them with his ideas is compelled to give his

words in innumerable passages so changed a meaning, that we may well ask whether the result is still Kant.

But in this work we are less concerned with the new outlook regarding the nature of knowledge. Its only importance here lies in the fact that the relativity theory had to a certain extent prepared mankind in the new century to take in the still more fundamental and revolutionary consequences which arise out of the other modern physical doctrine, Planck's quantum theory. When the hitherto accepted laws of our 'pure forms of perception' proved to be too narrow to include the new physical knowledge, it was an obvious step to ask whether something similar might not also be true of the two famous 'categories,' substance and causality. We have indicated that doubt already arises regarding the first of these, in the relativity theory. We must now go both into this question and into that of causality at somewhat greater length.

The Development of the Concept of Substance in More Recent Physics

We have already seen that electrons and protons are just as much substances as the old mass-points, and there can be no doubt that Bohr's original model of the atom, with its analogy to

the planetary system, is well within the customary mechanical mode of thought. But this model carried in itself from the start the seeds of later revolutions. In order to deduce correctly the observed facts (of spectroscopy) Bohr was obliged to incorporate in his theory two assumptions which went considerably beyond the limits of classical physics; one of them actually contradicted classical electrodynamics, while the other was at least devoid of all foundation in it. These two elements ended by actually disrupting, as it were, the original Bohr model, and in the process the new and far-reaching consequences of which we are about to speak, ensued.

The essential content of Planck's quantum theory may be expressed as follows: in the classical theory, energy is regarded as a magnitude capable of continuous variation, whether it be the energy of the electromagnetic field, radiant energy, energy of the motion of molecules and atoms, heat-energy, or any other kind of energy whatsoever. In other words, its magnitude may have any value whatsoever, and it may be transferred in any amount from one body to another, for example, radiated from an atom as light, or conversely, absorbed from radiation by an atom. This assumption is abolished by Planck. According to his theory, based in the first instance upon the experimental facts of heat and light radiation,

energy, like matter, can only be transferred in multiples of very minute but quite definite 'quanta.' Just as matter exists in no smaller particles than atoms, or protons and electrons, so does energy exist in no smaller amounts than the quanta. However, this is not to be taken, as is commonly supposed by the non-scientific, in the sense that a definite atom of energy exists; on the contrary, the magnitude of this smallest amount of energy which can be transferred depends upon the frequency of the light to be absorbed or emitted; it increases in proportion to this frequency, and is thus for violet light (frequency about 800 billions per sec.) twice as great as for red light (about 400 billions).

We now reach a point at which it is simply impossible to proceed further without the use of mathematical formulae, hence I must ask the reader's pardon if I make use of one. It is the magic formula $E = h \nu$, which expresses mathematically the fact that the energy quantum is proportional to the frequency. It is so simple a formula as to be intelligible even to a person who has not seen a mathematical formula since his schooldays.

The factor h on the right is the famous Planck's quantum of action; it is a number of universal validity which, in metric units (centimetre, gramme, second) has the excessively small value

6·55 thousand quadrillionths (or 0·0000 etc., 655, the 6 being in the 27th decimal place). The amount of energy which can be transferred is always a multiple of the product of this amount h and the frequency ν of the light, and thus increases proportionately with the latter.

In order better to see what this means, we must change this equation around a little. In every process of oscillation, the duration of a single oscillation, which we will call τ, is obviously equal to the reciprocal of the number of vibrations per second, that is, the frequency. For example, the note in music has a frequency of 435 per second, hence each vibration lasts 1/435 seconds. Hence quite generally, $\tau = 1/\nu$, and if we transfer the ν to the left-hand side of the equation, making it $E/\nu = h$, we see that we can equally well write it $E\tau = h$. This means to say that Planck's constant is equal to the energy transferred multiplied by the time of a single oscillation. Now since the time of Euler and Laplace, the product of energy and time has been known as *action*, and hence h is called the *quantum of action.* In mechanics it is shown that, alternatively, action can equally well be defined as the product of impulse (mass × velocity) and distance; hence the two expressions $E\ t$ (energy × time) or $I\ s$ (impulse × distance) are equivalent; both are actions. Hence Planck's doctrine can

be stated in the form that, in all atomic processes, the 'actions' occurring are multiples of Planck's h. No process is known in which a lesser action than h has ever been observed; indeed, as we shall see later, it can be shown that no such process *could* be observed. But we cannot yet discuss this point. We will attend for the present to the problem of substance; we are now able to formulate it quite precisely, by the aid of the new concepts, as follows:

In the new physics, neither masses nor energies exist primarily, but only actions. That is to say, we have not, primarily, a something occupying space, a Something to which or with which, secondarily, something happens. We have only a Something which occupies at once time and space, namely 'action,' and the fact that this Something is 'quantised,' that is to say, exists only in multiples of the unit quantity h, is the reason for the fact that matter and electricity also occur in 'atoms' or elementary amounts, and that radiant energy also occurs in the form of 'Light Quanta.' The classical concept of substance is thus obviously superseded. In the essence of the latter is the statement that it is necessary to postulate in the case of every process a 'carrier,' which itself is unchanged with time. This is what Kant meant when he said: 'In all changes of phenomena substance remains unaltered, and the quantity of

the same is neither increased or diminished in Nature' (*Critique of Pure Reason*). This distinction between substance and 'accident' is therefore finally abolished in modern physics.

We must not allow ourselves to be rendered doubtful regarding this thesis by the fact (often stated in popular criticism of modern physics) that physics defines the quantity called 'action' by means of the earlier concepts, energy, etc. We must here distinguish between definition and definition. In the sense of a methodical teaching of physics, which proceeds from observed phenomena to fundamentals, in other words, in the sense of inductive instruction, such concepts as action or elementary electric charge naturally appear at the end of the journey, while such as force, intensity of light, etc., are met with at the outset, since they refer directly to our sense impressions. But in the sense of a deductive system of theoretical physics, which undertakes to 'explain' the world theoretically on the basis of certain fundamental principles (and this is the final goal of all physics) we must, conversely, begin with the fundamental concepts which are reached at the end of the inductive process. Expressed in the terms of modern epistemology: what stands gnoseologically at the conclusion, must necessarily be ontologically at the beginning (in the inductive sciences, not in mathematics).

Hence no valid objection can be raised on these grounds to the above statement that the quantisation of action is primary, that of matter secondary or consequential. Gnoseologically, the former is arrived at through the latter.

But the classical concept of substance is becoming untenable in modern physics from quite another point of view. We said above that within the frame of the electromagnetic world-picture, the protons and electrons bear indubitably the characteristics of substance, but this statement cannot be any longer upheld, since we have learned to resolve even these 'corpuscles' into processes. We said above that physics, round about 1900, distinguished strictly between two kinds of radiation: light radiation (in the widest sense = electromagnetic radiation) and corpuscular radiation, the latter always having a velocity less than that of light, and, as then supposed, no wave-like characteristics. It has recently been shown that the latter opinion is erroneous; the characteristic phenomena of wave radiation, diffraction and interference, have also been demonstrated in the case of corpuscular radiation. This discovery (by Davisson and Germer, 1927) did not take place by chance, but was led up to by a new theory which undertook to interpret material corpuscles themselves as wave phenomena. In order to avoid going too far into matters

of physics, we must confine ourselves here to this mere indication. It does not of course do justice to the genius of de Broglie and Schrödinger, to whom we owe these new discoveries, and it also fails to express sufficiently the double character, wave = corpuscle, which according to this theory is the property of matter. But we must resign ourselves to passing over this point. According to Schrödinger's theory, an electron or proton flying through space may be regarded as what he calls a wave-packet, that is to say, it consists of a multiplicity of waves of numerous different frequencies, which in general destroy one another in the whole of space by interference, and only reinforce one another, in the neighbourhood of a certain spot, so far as to lead to a sensible amplitude. This spot is not stationary, but travels in space with the waves, but not with their velocity, but with one considerably smaller, the group velocity as it is called. The latter is what we term the speed of the corpuscle in question. Calculation shows that the localisation of this corpuscle, that is, the determination of the spot at which the wave energy is concentrated, can be effected the more sharply, the greater the number of different frequencies represented in the wave-packet. If only one frequency exists, no locality can be stated; a wave of this kind fills the whole of space with equal intensity.

This statement is of fundamental importance for our later discussion of the principle of causality. For the present, we will confine ourselves to the concept of substance. Anyone learning the above facts for the first time will naturally be at once inclined to say that, even when we have succeeded in resolving the two final material corpuscles, electron and proton, into waves, we are still a long way from having got rid of the notion of substance. For in order to imagine a wave, we must, after all, first postulate a substance as carrier of the wave process. Waves can only exist when something is there to perform the necessary oscillations. This objection is already refuted by what we said above concerning the popular interpretation of so-called ether waves, that is, electromagnetic waves. Oscillation and wave mean, in modern physics, any periodic change in any quantity, which can serve as the measure of any physical state. If the temperature in a room were to change periodically (say go up and down by 10 degrees every quarter of an hour) the physicist would say that it is executing oscillations with a quarter-of-an-hour period. Here he is not thinking of the actual up-and-down motion of the volume of mercury in a thermometer, but of the physical state itself (temperature) about which the thermometer informs us. Exactly the same meaning is to be attached to the

statement that broadcasting and light waves are electromagnetic waves. This sentence means no more than that we are dealing in the case of these processes with periodic changes in the electromagnetic field, changes which are propagated with definite velocity in space. To this the apriorist will reply at once: Good, then this electromagnetic field, or its supposed field-strength, is the substance we are dealing with; and even if it be a substance other than the matter of mechanics, it is nevertheless a substance, and hence there has been no fundamental change.

This objection is valid when it is applied to Maxwell's electromagnetic waves. But it would be wrong to apply the same conclusion to the waves of Schrödinger's theory. These waves employ, strange as it may seem, no substantial carrier any longer; they also are naturally periodic changes of some physical magnitude (denoted in the theory by S or ψ and called the field scaler), but the peculiar fact is this, that we can find no physical interpretation for this quantity, and hence for this reason are not permitted to rank it with the field constants of the electromagnetic theory of light. Schrödinger himself, it is true, at first believed that the square of this quantity could be given the sense of an electric charge-density. But in developing this theory further, Born, Jordan and others have shown that this

ominous S or ψ cannot reasonably be given any other interpretation than that of the mathematical probability that the electron or proton will be at the point in question at the given time. But a mathematical probability is not a physical reality like a temperature or field strength or what not. With this new interpretation, the whole material notion of substance disappears in our hands. What remains of plain, real, hard, sharp, heavy, etc., matter? A certain probability depending on formal mathematical laws, that energy or impulse are observable at a certain world-point!

First we resolved the limitless variety of materials in the world around us into the atoms of 92 elements, of which chemistry teaches us. There could be no serious objection to this, since we still kept to the limits of the concept of substance. Then we resolved these 92 atoms into the complicated play of two kinds of electrically charged primary particles (protons and electrons). Still all is well: the old notion holds, only that our picture of the world is wonderfully simplified. The physicist now built us up the whole material world out of a minimum of assumed quantities of substance, the few quantities M, m, e, h, c; all the differences of materials and processes familiar to us were reduced in principle to the general laws obeyed by these ridiculously few elements of reality. In other words: Everything that we

regard as simply existing, and persisting throughout the changes of phenomena, is already very little more than mathematical form.

Now follows the last step, which could have been foreseen in view of the above facts: we reduce also these few last substantial qualities to formal conditions of processes of wave-like nature, the carrier of which, however, is no longer a substance, since it possesses no properties which enter into the discussion of the problem. It is of fundamental importance for an understanding of our present-day world-picture to realise that to assume the existence of a substance means to assume something the natural qualities of which in some way influence the processes which take place in it or by its means. When ordinary (mechanical) waves run over water surfaces or along elastic strings or what not, the form of the process is always the same, and is always represented by the same mathematical formula; but the 'medium' nevertheless always has a certain influence upon the real course of the process; inasmuch as the velocity, for instance, of the waves depends upon its properties.

But for the waves of the new wave mechanics which we are considering, it is precisely characteristic, that in their case no such fixed property of their carrier is made use of; it is solely a matter of the formal laws of the process; and the result of

this is, that physics is able now to dispense entirely with a carrier or medium. Physics is not interested in dealing with things about which it can say nothing. This is no good ground for it to deny the existence of such things; perhaps something can be done about them by means entirely other than of physics. Physics can have no objection. But in constructing its own system, it simply leaves them out. We shall see below what curious philosophical consequences follow from this.

Let us summarise what has been said. Present-day physics has completely abandoned the classical concept of substance. It makes no further distinction in principle between a space-filling something, and the time-filling processes which take place in it; it knows only something which always occupies at once both time and space. If, as many philosophers anxious to save apriorism do, we describe this common thing as substance, there can be no objection, only one should realise clearly that we are now dealing with something quite different from what was formerly described by the term. Naturally no physicist will dream of denying that 'something' is there which distinguishes the world from nothing, from an empty dimensional scheme of order x, y, z, t. In this sense, it is just the physicist who will always remain a realist; absolute idealism is unacceptable to him, in so far as it undertakes to construct

the world only from the side of the cognising subject. But the physicist of to-day has learned – an enormous advance from the point of view of his world-view – that his atoms or electrons or what not are no longer to be regarded as rigid lumps of reality, from which no path can be found into the mental and spiritual sphere; he sees, on the contrary, that all these structures are forms in perpetual flux, which are only of interest even to him as regards their form. With this view, every variety of materialism is superseded.

But not only materialism but mechanism – taking the word in a broad sense – has no longer any support in modern physics. This brings us to the second category, that of causality. The classical view (the Laplace ideal) is that of the strict determination of all natural events by the initial state and the laws of nature. We will so see which modern physics puts in its place.

The Problem of Causality

Doubts concerning the strict validity of the classical ideal have repeatedly cropped up in the course of history, but have never attracted much attention. It appeared altogether too evident to all scientists, that scientific research and the discovery of causal relations were one and the same thing. While this still remains true to-day

to a certain extent, it had not been previously clearly understood, that what in this connection is meant by causal relationship is a view not inconsiderably specialised, concerning which one might be doubtful whether it would really furnish an adequate account of the world. We must first go into this point more fully.

To give a 'causal explanation' of a process or a set of facts means, in common parlance, to answer the question why this process or set of facts is as it is. We cannot here develop the whole problem of causality; to do so would alone require a large volume. It must suffice here to remark, that the answer to this question – why? may be given in all sorts of different forms. But classical mechanics allows only one of these forms to be regarded as valid in physics: the reduction of the process or set of facts to be explained to laws and initial conditions. The phenomena of motion of the heavenly bodies which we can observe are taken to be explained, because on the one hand we know Newton's general law, which governs the forces exerted by all heavenly bodies upon one another, and secondly, assume a single quite definite initial state as given. Indeed we can and must say, still more precisely that, as regards classical mechanics, even the general mathematical form of such laws is prescribed; it must be that of differential equations of the second order

(in mathematical terms) in which neither the place nor time co-ordinates occur explicitly (since otherwise the laws would not be general, but only hold for definite places and times). We have already remarked above that the latest quite general laws, those of the relativity theory, are also of this type.

Is that really necessary? Can it be shown that our need for causal explanations can only be finally satisfied, and really is finally satisfied, by bringing natural phenomena into the frame of this ideal, which was stated by Laplace with all possible clarity? No profound philosophical thought is necessary to see that this is not the case. It can neither be proved that only this classical mechanical view and no other can satisfy our need for causality, nor that *it* completely accomplishes this end. For it is quite evident, in the first place, that the laws of heat, etc., discussed above, which depend upon the application of statistics, satisfy our need for causality equally well though they are of an entirely different type from the classical laws. If I can perceive that, for example, the macroscopic processes taking place in conduction of heat or diffusion all amount to a less probable distribution of molecules becoming a more probable one, this satisfies my need for causality just as much and just as little as one based upon classical mechanics. When anyone shakes up

black and white sand in a vessel together, he will not expect to get anything except a uniformly grey mixture. If it can be shown – and this is actually the case – that the laws of heat just referred to, and innumerable others as well, all come to the same thing in the end as this process of shaking up, our demand for the reason is satisfied, as far as it seems possible for it to be.

It may naturally be objected that a further problem still remains unsolved, namely why nature in all such cases obeys the law of large numbers (for this is what the matter always amounts to). But the supporter of statistical laws readily replies to this objection by saying that the problem is certainly not more serious than that remaining in the case of the classical explanation of nature, namely that of the origin of the exact laws, of the type assumed by it. The fact that nature should take it into her head to work exactly according to the law of the square of the distance (to take a single example) is finally not easier and not more difficult to understand than the validity of the law of large numbers, what is called the *problem of application* of the calculus of probability. Indeed, we are obliged honestly to confess, that, on close consideration, the latter behaviour of nature is much more self-evident to us than the former. When a perfect die gives equal numbers of all six possible throws, the fact

does not seem to us to require an explanation. We regard it as self-evident, and ask: Why should it be otherwise? What in all the world could cause the die to prefer to turn up 5 or 3? Our need for causality is only excited in this case, when what actually happens is other than the law of large numbers leads us to expect. In this case, an instinctive feeling tells us that there must be a special 'reason' for an excess of one number over the others. If on the other hand no one number turns up oftener than the others, nothing leads us to enquire further. But fundamentally the same thing is true in the case of all 'explanation' of nature by means of statistical laws. On the other hand, when quite definite mathematical formulae appear in fundamental laws of the classical type, without our being able to see directly why they might not be other than as they are, we feel that an explanation is required. Why must planets and all bodies attract one another according to the law $\frac{1}{r^2}$? Why not $\frac{1}{r^3}$ or some other function of r? To put the matter shortly: in the classical scheme, the final fundamental laws remain contingent, they might also be other than as they are; and although we may be able to reduce one to another, or two to a third, this contingency of actuality, of the general law, remains.

These considerations alone make it clear that we have not the slightest reason for adhering once

and for all to this classical picture under the delusion that it alone can satisfy our need for causality. But for the physicist at least, it is not in the first place a matter of what best satisfies our real or imaginary epistemological needs, but what best fits the real world. In reality, the general and hitherto unshaken conviction which has ruled European thought since the Renaissance, of the validity of the famous 'great eternal iron laws,' is by no means an inevitable 'category' of human intellectual life, as the apriorists, of all schools maintain, but only itself a product of historical development, which was clearly grasped and adopted since the days when Newton and his contemporaries created the new physics. *The propositions of classical epistemology are prophecies after the event.* When the system of classical mechanics had come into existence, it was decided, after the event, that it absolutely had to be as it was. If this is the case, it follows at once that development may again carry us beyond it, and this has actually been the case, to the pain of all philosophical theorists who suppose that they can decide from within themselves what science is, without first examining the actual content of present-day science.

What we maintain, therefore, is in short, that just as the conviction of general and all-embracing natural law was a product of historical

development, and as such a necessary and indispensable intermediate step in human knowledge, so also to-day, the new formation of concepts which has become necessary may and must claim to be regarded as a new and higher stage of knowledge and not to be dismissed from the outset as mistaken, simply because it contradicts accustomed ways of thought. What is the extent of these new ideas, and how has physics arrived at them?

It is not very easy to impart to layfolk, who cannot be expected to understand mathematical language, even a notion of what has here taken place, for the whole affair has actually developed solely in the field of mathematical physics. It is not the result of new experimental discoveries, but of the attempt to understand theoretically what is already known; to explain it, in the first instance, in the classical sense. We have seen above that this theory of Schrödinger's ascribes to our previous 'material corpuscles' a wave-like character. Eddington made the witty proposal to call this cross between a wave and a particle a 'wavicle.' Now such a wavicle exists in a position which is the more sharply defined, the greater the number of different wave lengths (on frequencies) which go to compose it. On the other hand, according to the general principles of wave mechanics, there corresponds to every wave length a certain impulse I, or, what amounts to the same thing,

to every frequency ν a certain energy E according to the equation $E/\nu = I\lambda = h$. From this it follows that the more definitely the position at a given time is to be stated, the more indefinite does impulse or energy become, since both become less definite the larger the number of single frequencies or wave lengths taking part in the wavicle. When this idea is worked out mathematically (we omit the working here) it is found that a quite definite numerical relationship can be stated between the errors made, on the one hand, in determining the position (the co-ordinates) and the impulse of such a particle, and on the other hand in determining it at a given time. If, namely, we designate these errors by the symbol Δ, the position co-ordinate as usual by q, the impulse by I, the energy by E, the time by t, we have $\Delta q \Delta I \geqq h$, and $\Delta E \Delta t \geqq h$; that is to say, it is impossible to make the product of the two errors less than h. This is the famous *Heisenberg Uncertainty Principle.* A more general form of it, which we will pass over here in order to avoid mathematical difficulties, is the fundamental equation of the whole modern theory of spectra, which coincides with the modern theory of matter.

When Heisenberg put forward this equation in 1927, it at first only had for its object the classification of all known experimental results of spectroscopy, and it still has this significance

to-day. But Heisenberg himself at once recognised its much wider fundamental significance, which lies in the fact that, it eliminates the Laplace ideal from physics. For this ideal demanded, as we have seen, that we should know, concerning the physical system considered, at a quite definite time both position and impulse of all mass-points of the system, if we wished to calculate the system. And just this is declared by the Heisenberg relation to be fundamentally impossible. If we desire to determine the positions with greater and greater accuracy, the impulses are necessarily determined with less and less accuracy, and when the error in the former is zero, i.e., the position is determined exactly, the error in the impulse becomes infinite; that is to say, it remains entirely undetermined and uncertain. The same is true of energy and time.

Hence Laplace's ideal is already untenable as regards the assumption that a knowledge of the 'initial state' (momentary world section) could be obtained. And this does not mean that such a knowledge is merely a practical impossibility. That would be merely a technical difficulty; Laplace was naturally fully aware that one could never, in practice, obtain the ideal data. What we are now dealing with is a fundamental impossibility. The material world is not constructed in the way assumed by Laplace; or in other words,

it does not consist of individually separable points of substance, to each of which a definite place and a definite velocity can be ascribed at any definite time; it consists rather—yes, of what? At any rate of something else, which by its nature does not allow of the Laplace ideal being realised.

I point out expressly that this result may also be reached from quite another side, as already stated above. But the result is the same: the classical mechanistic idea proves to be a prejudice, a crude mode of thought based upon notions derived from macroscopic processes, and incapable, in the nature of things, of dealing correctly with the sub-microscopic relations in the interior of the atom, just as little as the statistical results of an insurance company can give us any data concerning individual fires, suicides, accidents, etc. In the *subatomic region, all concepts familiar to us in the macroscopic* are useless; and new ones have to be created. These are necessarily difficult to picture, since the world we are able to perceive directly is the macroscopic, not the subatomic. Only mathematical abstraction can do what we need. It is first obliged to build into empty space, so to speak, and then to show, at what points of its structure the secondary concepts there deduced can be made to agree with the world of experience. That is the meaning of the Heisenberg theory, and I must state

expressly that the above attempts to give the reader a notion of his Uncertainty Principle are already simplified at the expense of strict accuracy. Only the mathematically trained can properly grasp its meaning. This is a painful fact, perhaps most of all for the physicist himself, who is usually no great friend of abstract mathematical lines of thought. Hence it is not an accident that the development of the new physics is more in the hands of mathematicians than physicists, but this cannot be altered. Nothing else was really to be expected. For what right had we to assume that nature was, in its ultimate structure, so formed as it appears to our coarse senses?

It is natural for the layman to object at this point, that our former idea of strict causality in nature has proved of practical value in innumerable instances, that our whole technology and industry depend upon it, and that it is quite inconceivable that all of it should be pure delusion. Naturally it is inconceivable, but then modern physics makes no such assertion. On the contrary, it allows that the 'laws of nature' hold practically without exception on the macroscopic scale, upon which the whole of technical action takes place, just as it has shown in the case of the laws of heat and so on.

It would be completely erroneous suddenly to regard the laws of nature as abolished. They

are not less certainly valid because they have turned out to be simply statistical, for, as we already mentioned above, in all our ordinary macroscopic laws we are always dealing with the combined effect of trillions of atoms or quanta of action, and with such numbers statistical laws are absolutely exact for all practical purposes. Hence, no piece of knowledge is actually rendered fundamentally invalid; it is simply given a background of still deeper knowledge, so that what we hitherto regarded as primary is now seen to be secondary. We realise that the 'laws of nature' with their, in any case extremely puzzling, contingency are not contingent at all, but must be regarded as themselves deducible. But this deduction is not, as we have always hitherto imagined, a matter of reducing all laws to one single, quite definite, but again contingent law, but is in nature identical with the reduction of the laws of heat to statistical mechanics. If we follow this notion out to its logical conclusion – it could not hitherto be carried out quite completely, since we have not yet sufficient insight into the matters—it appears possible, that, finally, all natural law may be reduced to the calculation of probabilities.

Since this assertion must at first seem very strange to the layman, we will consider it a little more closely. For this purpose we will construct a highly simplified, and most probably, not quite

true picture, which, however, will exhibit some characteristics of some essential peculiarities of present-day physics.

We stated above, that the quantisation of matter and electricity into atoms and elementary charges *e* is most probably according to our present views, to be regarded as a secondary result of the primary quantisation of action (Planck's quantum *h*). Let us assume that the world consists of nothing but Planck's quanta. We said above that these always occupy both space and time. It is however probably more correct to say that they in themselves are neither temporal nor spatial, but that space and time are only the form in which the ordering of these quanta appears to mankind (and probably also to other beings).

Here again the layman will stumble. Yes, but does not the concept of order assume space or time or both? Are we not, therefore, moving in a vicious circle? Answer: when the mathematician of to-day (and with him the mathematical physicist) speaks of order, he is thinking of something of which order in space and time (co-existence and sequence) is only a special case. In order to understand this, let the reader ponder the following: We take all the notes which can be produced in a violin, which we imagine supplied with any required number of higher and lower

strings. Every possible note can be characterised by two statements: its pitch and its loudness. Both can be stated in figures, the first for example by the frequency (say $n = 435$ per second) and the second by the amount of energy per second. The mathematician expresses this by saying that the notes in question form a 'two-fold infinite manifold,' which means no more than this, that every single number of this number or manifold is distinguished by two figures. In the present case (a violin, in which the pitch can be varied continuously) we have a manifold continuously variable in both respects (in both dimensions as the mathematician says). The notes follow one another continuously, without a break, both as regard pitch and loudness. If on the other hand we use a piano, we have continuity only as regards loudness; as regards the pitch we have only a 'discontinuous' manifold.

In both cases we can if we wish represent (as the mathematician says) the manifold of notes by a 'point manifold'; we need only plot the two numerical values (n and I) characterising each note, in a co-ordinate system, then each point of the plane in the right hand upper quadrant, corresponds to a definite time and conversely, in the case of the violin. When on the other hand we take the case of the piano, we still have a point on the plane for each note, but not

conversely, a note for each point on the plane; or rather, all *possible* times would arrange themselves as a sheaf of parallel lines (parallel to the intensity axis) since notes exist only for certain discrete values of the number *n*, but these are capable of all possible intensities. If also for the latter we were to admit only values variable in jumps, the picture of all possible notes would form a 'grating' consisting of nothing but single points.

This simple example thus illustrates what present-day mathematics understands by the term 'order' of a manifold. In exactly the same way, we can imagine objects of all sorts, colours, equations, human beings, accidents and so on, arranged in order. The sole requirement is that every member of the *quantity* in question can have attached to it one or several numerical values as numbers or co-ordinates, whereby it is distinguished from other members.

We have then always to distinguish the two main causes discussed above: whether these numbers form a succession of figures which change in jumps—in the simpler case whole numbers—or whether we have a succession which changes continuously. In one case the numbers in question form a continuum as regards this dimension, in the other an aggregate of discrete members.

When we say concerning the above picture of present-day physics, which is probably too simple,

that the world perhaps consists of nothing but single quanta of action, we mean, as we now well understand, that we are actually dealing in this case with a discontinuous manifold, each member of which is characterised by four numerical values $x\ y\ z\ t$, which may simply be regarded as whole numbers. It is this order which appears to us as the space-time order. The reason why one of these dimensions, t, appears to us so entirely different from the other three, lies, according to the relativity theory, in the fact that this co-ordinate appears in the plan multiplied by $i = \sqrt{-1}$.[1]

But thus it is clear to us that (and why) the postulate of the old epistemologists, that the world must needs be thought of as continuous in space and time, is a pure *petitio principii*. We may not be able to form other than a continuous *picture* of it, but we can very well think of it as discontinuous. Every cinematograph shows us that an actually discontinuous succession of pictures is taken, owing to the coarseness of our sense of sight, as a continuous process. Why should not the whole world, as Boscovich imagined some 300 years ago, be like such a cinematograph? The principle of the cinematograph has long been known under the name of zoetrope, etc.; we have

[1] Whereby I do not mean to say that the problem of phenomenal time is solved.

already referred (p. 10) to Planck's remark concerning the old principle, 'natura non facit saltus.'

However, here we are not interested in the problem of continuity as such, but we are only alluding to it in order to make the present position regarding the problem of causality more intelligible. According to the classical view, the laws of nature must have the form of differential equations of the second order. This is the mathematical formulation of the continuity in space and time of all natural processes; in order to master it, Newton and Leibniz had to invent the differential calculus. For this 'Calculus of infinitesimals' is the method by which we can deal mathematically with quantities which vary continuously. To-day we are confronted by the question whether we should not seriously attempt to arrive at the fundamental laws of nature in quite a different way, by means of pure arithmetic, namely the calculus of probabilities, and only apply the differential laws as approximations (which method can be formulated exactly by mathematics). But this then means nothing else than that the world is calculable so far and no further than the application of probability, that is statistics, is permissible. And this is obviously everywhere the case, but only when we have repetition or the possibility of repetition. Everything that happens

only once of necessity eludes treatment by statistics. We then arrive at the conclusion that the world is only predictable and calculable by the investigating mind in quite a different sense from the ideal of Laplace. It is only possible to apply calculation in all such respects as are amenable to statistical method. That is a great deal; much, very much, more than we used to imagine, but – it is never all. The determinism of Laplace's picture is a pure chimera. The world appears to us to-day as a tissue of necessity and chance; but the first of these represents only the outward aspect; as it presents itself directly to the coarse senses of man. Internally, the world is something quite different from a huge machine, all its quanta of action are present completely independent of one another, none of them is in any way physically conditioned in its existence by the others; only when we have a certain collection of a large number of such quanta can we expect with some probability that there and then a certain other something will be present. It cannot be denied that this is something quite different from the classical view.

We will now consider this whole matter from another point of view, that of the problem of contingency, long known to philosophy. Under this term we understand the question why a world exists, and why it is as it is. When we examine it

more closely, the problem resolves itself into three questions. The first, why something and not nothing exists, is in itself unanswerable; it leads to the problem of existence and the so-called cosmological proof of the existence of God. We shall pass over it, remaining satisfied with the fact that our world does exist. But this world is then contingent, that is to say, might-by-chance-have-been-otherwise, in two respects; a fact we can see more readily by returning for a moment to the classical picture of celestial mechanics. Here we first have the laws, for example Newton's law of gravitation, and, as we have already said, we can at first sight see no reason why they should be just what they are and not otherwise. That is the 'thusness' contingency of the world in the classical view. But, furthermore, when we have the laws given it is still possible to imagine an infinite number of different worlds, in the sense here of solar systems, etc. The laws alone will never enable us to deduce that at some particular point of space a sun of a certain size exists, surrounded by certain planets. And hence quite generally, the totality of all physical laws in no way affords any reason for just the actual distribution of electrons, quanta of action, etc., and no other.

We only need to imagine two atoms interchanged, to have a world different from the real

world. This contingency of the actually existing is clearly expressed, according to the Laplace ideal, by the 'initial conditions.' These may be purely arbitrarily settled, but – and this is characteristic for the standpoint of classical physics – they can only be settled once. As soon as they are decided, they and the laws together settle the whole course of world history unambiguously.

From this point of view, the meaning of the new physics can be very clearly recognised. It consists in the fact that this limitation of the contingency of the actually existing to a single 'world section' is removed, and instead distributed over the whole course of history, while the 'thusness' contingency (that of the laws) is perhaps entirely abolished, or at any rate replaced by something else. According to the new physics, all elements of action are, as we have said, completely independent; in this sense the whole course of the world is, physically speaking, uniformly contingent in its existence. There are no such things as contingent laws, that is, laws that might be otherwise, what we call laws are only statistical rules, which are as it were only made up after the event (like all statistics), concerning the completely independent quanta; we count up the elements of action in nature and find that certain combinations repeat themselves according to the rules of probability in the very way that we regard as

self-evident in the case of dice or roulette. And all this is then called 'studying physics.'

I have put the matter here as crudely as possible, perhaps, or probably, things are just a little different from this, and considerably more complicated. But I wished to give the reader in this way as impressive a picture as possible of the revolution which has taken place in our physical thought. The essential points will now have been made sufficiently clear. And with this we have dwelt sufficiently upon the physical in the narrow sense, and we will now turn to the philosophical consequences, in so far as we have not already dealt with them in the foregoing. We are now going to deal with the actual fundamental questions of philosophy: life and soul, God and freedom of will. We shall see how entirely changed to-day is the aspect of these problems for natural philosophy. We begin, for reasons of method, with the problem of body and soul.

V

THE PROBLEM OF BODY AND MIND

As we all know, philosophy has hitherto failed entirely to solve this problem, nor has science been able to put forward any decisive matter leading to its solution. The complete want of all basis for comparison between the psychical and the material has hitherto prevented either of them from being referred back to the other, or the two being referred to a third, although their connection is obvious. We will not here discuss in detail the various theories, materialism, spiritualism, parallelism, dualism, and identity; the reader will find them stated in any good introduction to philosophy or psychology.

New light has been suddenly thrown upon this hitherto hopeless problem by the new physics. As far as I know, the first to point this out clearly was the famous English physicist and astronomer, Eddington, who showed that present-day physics appear to lead to the spiritualistic solution of the problem. As we saw above, physics now dispenses with a 'substance,' and to use Weyl's expression

'deals only with the formal formulation of the real.' But on the other hand, physics will not and cannot deny that the real world must nevertheless be something more than a mere mathematical thought. That 'form' which is now the sole subject matter of physics, seems to cry out to be given a content, as Eddington says, and hence there appears to be no obstacle to our regarding the spiritual as this content. We should thus come in touch with the actual reality of the world at one point only, namely within ourselves, whereas everything else, known to us only through the evidence of our senses interpreted by our reason, would only reveal to us certain formal laws of the behaviour of this world substance, the spiritual, the laws of physics forming the lowest stage of this revelation. Others have put forward very similar ideas to those of Eddington, for instance the physicist Riezler, the colloid chemist, Harold Picton, and many others.

A doctrine of this kind is naturally at present merely a programme and not a real solution of the problem, for it still remains to be shown how the material world is to be deduced from the purely psychical data. It is obvious that spiritualism has hitherto always failed in this respect. It has never succeeded in deducing even the properties of a hydrogen atom from data of this kind. What is new in the present situation is the fact that such

a proposal no longer appears so completely absurd as it did even twenty years ago. For just that which hitherto presented an insuperable obstacle, namely the 'rigid lumps of reality' of ordinary atomic theory, has been resolved into pure form, and a mathematical form is in itself something psychical, and belongs, as Plato already saw, directly in the realm of the Logos, which is behind all things. This opinion is also shared by the famous English physicist Jeans, who wrote a short time ago:

> "The universe begins to look more like a great thought than like a great machine. Mind no longer appears as an accidental intruder into the realm of matter; we are beginning to suspect that we ought rather to hail it as the creator and governor of the realm of matter – not, of course, our individual minds, but the mind in which the atoms out of which our individual minds have grown exist as thoughts. . . . We discover that the universe shows evidence of a designing or controlling power that has something in common with our own individual minds . . . the tendency to think in the way which, for want of a better word, we describe as mathematical."[1]

[1] From *The Mysterious Universe*, by Sir J. R. Jeans.

In essence, this is the same as Plato's saying: ὁ θεὸς παντὸτε γεωμέτρει; only, this sentence stands to-day on quite another and a much broader basis than it did two thousand years ago; we can see to-day why it was premature when Plato wrote it. The way to Plato can never be other than via Democritus. Every attempt to avoid this fact and to anticipate the Platonic conclusion, without having completely absorbed all that Democritus has to tell us, is doomed to failure. There it stands; the hard, cold, sober world of matter with its atoms, the existence of which is to-day proven beyond a doubt. It is impossible to pass it by, and it is time for all idealists finally to accept this fact and give up their fruitless attempts to avoid it. Matter will only be finally subjugated by mind when we are really able to understand it as the product of psychical powers. Merely to postulate this as a fact, which is all that spiritualism has hitherto done, is not of the slightest use; matter and its worshippers, the materialists, simply laugh us out of court saying: here is a single atom, the simplest of all, the hydrogen atom. Show us what you can do! Show us how we are to understand it as the product of purely psychical potencies – then we will believe you. Now it appears as if spiritualism to-day can actually pass this test. I will not maintain that it has already passed it, but I

believe it to be undeniable that it is very close to doing so, and has every prospect of success.

We must, however, make a further observation here. I said at the close of the last chapter that a purely mathematical form obviously cannot very well be put forward as fully real, in other words, a mere idea alone cannot do what is required, an objection that has always been brought against Platonism. But if it is true that we have within our own selves direct access to true reality, to the 'substance' of the world, it immediately becomes clear that this substance actually possesses a dual nature, namely idea and will, Logos and Eros. For we ourselves not only perceive and know, but also will and feel. If the fundament of the world is like to ourselves in principle, the same must also be true of it and hence it must be this second side, that of will which turns the pure idea into concrete existence, exactly as in our own case; this is also age-old Aryan wisdom (Hindu, Schopenhauer and von Hartmann) which finds its classical expression in Faust's saying: in the beginning was the Deed. Perhaps it is something more than an historical chance that physics has introduced for what it believes to 'really exist,' the name of *action*. Words of this kind must naturally not be taken as the basis of philosophical conclusions, as unfortunately happens to-day in circles which do not think scientifically; circles that think

in words and not things. Words of this kind denote in science, in the first place, some quite definite and unambiguously defined concept, and it is an elementary logical error, a so-called *quaternio terminorum*, to found general conclusions upon the mere similarity in sound between such a word and a word in common use, such as 'work,' 'energy,' 'inertia,' etc. Physicists accustomed to clear thinking naturally find this intolerable.

Nevertheless every now and then we find that language exhibits an almost clairvoyant sense in the choice of many terms, and this appears to me to be the case here. I cannot enter into the extremely interesting story of the concept of 'action' in physics, and of the 'principle of least action,' depending upon it. But it almost seems as if the originators of this concept and of the principle named after it (Maupertuis, Euler, Hamilton) had a kind of premonition that it would one day become the foundation of the whole of physics, hence we may at least be glad that they chose this word, the double meaning of which is perhaps in this case not unjustified.

We must, however, never forget that what we are here stating is only a programme, and that the actual problem, with the new possibilities which depend upon it, is very far from being solved. The real problem of mind and body is not only the quite general, and if you like,

metaphysical question, whether, and eventually how, matter can be referred to mind or both of them to some third principle, but also the quite concrete question how a highly complicated group of electron movements, or whatever actually constitutes matter, can give rise in the brain to perceptions, thoughts, feelings, and volitions, and how conversely the latter can cause matter (i.e. ganglion in the brain) to telegraph back the required command to the motor nerves of the muscles. Only an incurable optimist could maintain that we have yet advanced any further in this direction; the only result of note in the last ten years is the fact put forward by Wertheimer, Köhler and others, that the material process in the nervous system is also something like a 'physical form' (*Gestalt*); hence not a mere chaotic disorder, but an ordered whole which is 'more than the sum of its parts,' just as a melody is more than the sum of the notes of which it is composed. The psychologists mentioned have performed the important service of drawing our attention again and again to the existence also of psychical 'form' (*Gestalt*).

It is clear that though the problem of mind and body is not thereby solved, it is nevertheless easier to comprehend that a physical form is imaged by a psychical process, than that the latter should be connected with a chaotic play of atoms or the

like. If the atoms themselves are nothing other than 'form,' we are presented with a possibility, of course so far only imaginary, of ultimately being able to grasp as a whole the psychophysical process that we described physiologically as movements in the brain, psychically as sensation; we should see it as a highly complicated form, the elements of which would be sub-forms, and so on down to the atoms and electrons.

It is a characteristic of the formation of psychical complexes and forms, that their elements are contained in them in quite a different way than in the case of material form. The notes of a melody, or still more those of a chord, the individual odours composing a perfume, for example eau de Cologne, are more or less lost in the higher structures of which they form the parts, or better the factors; in the latter case they disappear almost completely and nevertheless contribute to the final result, for if one of them be left out a decisive change may be made in this result.

The unsuccessful attempts to refer this participation of the components in such a 'form' to mechanical constructions such as the parallelogram of forces, strongly suggest that this highly characteristic generation of forms in the psychical realm may be the primary phenomenon, the physical case being only a special or limiting one. The result of modern physics invites us to attempt

a solution of the hitherto insoluble riddle on these lines. This will become much clearer if we now turn to the question which should really have been taken first but which I have been obliged to postpone so far on account of the considerations just mentioned, the problem of life.

VI

THE PROBLEM OF LIFE

THE problem of life consists of the question whether the phenomena and origin of life (the two are not entirely identical) can be referred to the laws of physics and chemistry, or not. The former view is called, somewhat inexactly, 'mechanism,' since physics was once regarded as fundamentally identical with mechanics; the latter view is called 'vitalism.' The controversy between the two has already been carried on for over a hundred years, and hitherto neither side has been able to convince the other. While thirty years ago mechanism was almost completely victorious among biologists, to-day vitalism has almost gained the upper hand; at least the great majority of biologists are convinced that the former arguments in favour of mechanism were not valid, and that the question must at least be regarded as open. A not inconsiderable number of leading biologists of the present day have recently attempted to take up a position 'beyond vitalism and mechanism,' admitting that organic form (Gestalt, self-regulation, etc.), cannot be reduced

to the laws of non-living matter, but rejecting the introduction of vitalistic factors such for example as Driesch's 'Entelechies,' since these do not contribute to a real explanation. We will now see how this problem appears from the point of view of the new physics.

We must first note that the great majority of biologists have unfortunately not yet decided to take serious account of the changed situation in physics. When they deal with the newly acquired knowledge at all, they are accustomed to be satisfied by pointing out that causality (= unambiguous determination) is not practically affected as regard macroscopic dimensions, and since biology only deals with this order of magnitude, it can safely leave pure probability to physics, which attempts to penetrate into the interior of the atom. While this point of view is very convenient, we nevertheless need to investigate a little more closely whether it is really correct. That is to say, to put the matter quite definitely, whether biology to-day has the right to regard itself as freed by this means from any necessity to take account of the new physics.

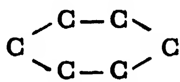
I maintain quite categorically that this is not the case; that, on the contrary, biology has every reason to pay the closest attention to the new position in physics, since probably here and here alone the way will be found to a final solution of the

hitherto insoluble problems of form and regulation. I must now attempt to give my reasons for this statement more fully, though I am quite conscious that in doing so, I am only taking the first tentative steps into a territory hitherto hardly explored at all, and am perfectly aware that what I am about to say does not present a solution, but only a programme for finding one.

The principle from which we must start is the statement already made above: so much of the world is calculable (that is to say, belongs to the realm of physics and chemistry), as is repeatable or repeated. Everything that only happens once is essentially by its very nature excluded from purely statistical physics. It cannot possibly be dealt with by the latter, since statistics is a science only concerning the average of what is frequently repeated. We have seen above that the part played by statistics is very much more comprehensive than has been commonly supposed. It is entirely possible that laws apparently perfectly definite in their form may be reduced to simple statistics, as we see perfectly in the case of the science of heat. Now there can hardly be any doubt today that, as we have here assumed, a simple probability calculation dealing with quanta of action would lead to the explanation of the whole realm of chemistry, with its practically inexhaustible richness in individual substances. Hence it is also

quite conceivable that this same method of statistics might carry us even farther, that is to say to organic form. I say conceivable, but not certain, for it is possible that matters are quite otherwise. In order not to overlook at this point the most important alternative possibility, I must first ask the reader to follow me into the unaccustomed territory of organic chemistry, for we shall not be able to proceed without alluding to it.

Organic chemistry is the chemistry of carbon compounds. The 'tetravalent' carbon atoms have the power of linking themselves together by one, or sometimes more, of their four 'valencies,' thus forming whole chains, rings, and so on. For example we have C–C–C–C in butyric acid, and



in benzine. The remaining three valencies of the carbon atoms are then linked to other atoms (most frequently H,O,N, i.e. hydrogen, oxygen, nitrogen), and the result is the formation of hundreds of thousands of compounds of more or less complicated structure; the unravelling of this structure being one of the most fundamental tasks of organic chemistry. When we know it, as for example in the case of indigo, vanilla, quinine, etc., we are able in the great majority of cases to make the substance in

question artificially—synthesise it as we say—and on this fact depends the whole of our flourishing fine-chemical industries, including dyes, medicines, inks, developers, perfumes, etc. Up to this point, the matter is comparatively simple, and although these innumerable compounds of carbon differ characteristically in many respects from most 'inorganic' compounds of other elements, no one doubts that the same chemical forces and laws are at work in both cases.

But a peculiar difficulty arises precisely in the case of those substances which play the chief part in living cells. Hitherto only very few of these have been discovered and determined with reasonable precision, but even in the case of these few, for example starch, cellulose, etc., a quite peculiar behaviour is observed, to which no exact parallel can be found in chemistry. Analysis by means of X-rays is able to give us fairly exact information concerning the 'fine structure' of most forms of matter. For example, we are able to determine with great exactness the precise arrangement of the atoms in a crystal of common salt, calc spar, or even sugar. But in the case of these organic constituents of cells, we are met with the somewhat unpleasant difficulty, that they do not appear to possess molecules of a fixed size, so that no fundamental chemical formula can be ascribed to them. They are built up of smaller molecules, united into

larger aggregates; thus starch and cellulose are built up of grape sugar molecules, the structure of which is known with entire accuracy. But it is impossible to say how many grape sugar molecules, for instance, go to make a starch molecule. Every attempt to determine this has always led to the discovery that these more complicated structures are made up of complexes of varying size.

How are we to explain this behaviour, when otherwise, in this world of chemical compounds, everything is so definite and unambiguous? I can find no other answer than this: these complicated compounds are such complex structures, that certain limits of stability are reached in their case. If we build a simple structure of bricks, it will be found to be very stable, so that not merely one but quite a number of bricks may be removed without the whole structure falling to pieces. When on the other hand we have a very complicated metal framework or the like, the omission of a single small part may seriously endanger the stability of the whole. Now modern physics teaches us that the apparent stability of a given chemical atom or molecule is an illusion. In reality, the whole of such a structure is in a state of perpetual change, for thousands of single quanta of action are concerned in its existence.

For this reason 'fluctuations,' as variations from the average are called in the theory of probability,

are not only not impossible, but on the contrary practically certain, given a sufficient space of time. This obviously does not matter so much in general in the case of inorganic molecules, or even the simpler organic molecules, as to change the existence of these molecules as a whole to a considerable degree; this statement means the same as that these substances are all well defined chemical individuals. But matters are otherwise in the case of the extremely complicated structures of the organic cell constituents, those which go to make up the real basis of life, protoplasm. Here the influence of fluctuations obviously becomes so great that complexes of variable size can occur with considerable probability, and we no longer have strictly defined chemical individuals, but only an assortment of different molecular structures, differing perhaps not only in size, but also somewhat in constitution. According to all that X-ray analysis has taught us, it appears very probable that this is the case.

But if this is true, then 'chance,' that is to say the determination of the singly-occurring elementary event, which is not calculable, suddenly plays a decisive part again in what hitherto had been determined with absolute certainly by statistics. The world would then be so constituted – it would not be remarkable if it were so – that its foundation, the elementary act, would be

completely free (or a matter of chance), while the resulting structure would be statistically calculable with at first moderate, then ever increasing accuracy as far as the realm of physics and chemistry, while at a sufficient degree of complication, an upper limit to the applicability of statistics would be reached, since we should then be dealing with structures which on account of their complication would only be very rarely, and finally never, repeated.

In other words, it is clear that there must certainly exist on the earth septillions of chemical atoms, sextillions of water molecules, quinquillions of sugar molecules, etc., but that identical starch complexes perhaps only exist in quadrillions or even trillions, and that in the case of still more complicated patterns the number decreases even more rapidly. We should expect this, since the law of permutations and combinations shows a rapid increase with the number of elements, according to the factorial numbers $n! = 1 \times 2 \times 3 \times 4 \ldots \times n$.

If this is the case – and I cannot see how any serious objection can be raised to the argument – chemistry, which is the science of the fine structure of matter, must have not only a lower limit but also an upper limit. This limit is reached when the complication of the structure is so great that its repetition becomes sensibly improbable.

From this point onwards the reign of chemical law will not of course be brought to an end, but will be modified by something new to which we must not fail to pay attention, if we are to understand nature. For it is obvious that matters do proceed farther; the world of organic forms is built up upon the world of substances, and it is equally obvious that certain systematic laws hold in it. When, therefore, chemistry inevitably leaves us in the lurch, it must be another kind of natural law which will open this new realm to our understanding and our ordering faculties. The question is, what is the nature of these new laws.

In attempting to pursue this question, we must first recollect the two fundamental facts discussed above: firstly, that the single elementary event is not calculable as such, but freely determined; and secondly, that the actual nature of this determination is possibly, or probably, a psychical process, for physics deals only with the purely mathematical and formal probability conditions of these processes, as we have already assumed. We perhaps approach more closely to the biological problem with which we are dealing if we recollect psychical facts known to everyone by experience.

As we have remarked above, the characteristic of psychical phenomena, as opposed to physical, is that several elementary psychical structures, as for example sensations, instincts, and the like,

do not in general unite 'additively' as do physical forces (e.g. in the parallelogram of forces) but that in their case we have the following general law: the lower psychical Gestalt is merged in the higher. This law is self-evident in the case of melody, works of art and the like, but it is also true for relatively very simple psychical qualities, for example, odours. The first question is whether these generally known experiences can be developed into a system of concepts with which scientific biology can work as precisely as physics is able to work with the conceptual system of ordinary mathematics.

The task here outlined has hardly yet been seriously undertaken. The fundamental concept would here be the Gestalt, perhaps in the form developed by the above-mentioned scientists, Köhler, Wertheimer and Koffka, and worked out in all directions by Friedmann in his magnificent philosophical survey *Die Welt der Formen.* Only he, like almost all supporters of idealism and vitalism, has not quite avoided the danger of the 'anthropomorphic short-circuit' and hence has not done complete justice to the achievements of mechanism in physics, and very little justice to the mechanistic method in biology. The saying *vestigia terrent* is certainly applicable to innumerable attempts of this kind.

Nevertheless, I believe that Friedmann has

pointed out in principle the true direction of future progress, when he demands that *mathematical methods based solely upon the concept of magnitude, and necessarily leading to mechanism, should be replaced by a method based upon the Gestalt concept as fundamental. Friedmann has seen quite clearly that mechanistic physics may be regarded as a limiting case of a much more general world-view*, the structure of which would be not purely metrical, but 'tectonic,' and hence much richer from the start. In this wider point of view, the point, or the element generally, does not appear as the primary concept but as a mere abstraction, just as in pure geometry of position it appears as the intersection of two lines. Thus also, the simple element of action in physics would in reality be a lower limiting concept, not possessing a true independent existence, but only as an element of a more comprehensive Gestalt or form, which alone would have real existence. In other words, the 'free' determination of elementary actions, left undetermined by physics, would be, in a manner characteristic of all psychical processes, in truth only part of a plan or form embracing it, or more exactly, a whole series or 'hierarchy' of forms, the higher of which would always absorb the lower and bring them to a higher synthesis.

This idea is of course by no means new. Plato came upon it intuitively, and Hegel attempted,

although in vain, to make it into a system of metaphysics. But what is new to-day is that physics itself calls upon us to attempt to develop this idea, since as we saw above, the determination of elementary actions, the contingency of which is spread over the whole world, is assumed by physics. The latter does no more than count them, but this fact is obviously no obstacle to our regarding them from quite another side, namely from the point of view of an all-embracing plan or meaning, a totality of Gestalts arranged one above the other. The only condition which must be made is that a new kind of mathematics should really be developed as an enlargement and prolongation of our present metrical mathematics. I regard it as quite possible that the newer logic which as we know has already given pure mathematics the means to develop itself, may serve as a basis for an entirely new mathematics which will treat, not the concept of magnitude, but that of Gestalt as its subject matter, being connected with our present mathematics by a simple limiting transition, metrical mathematics appearing so to speak as 'degenerate' General Mathematics, or the science of Gestalt.

A few beginnings of such a mathematics are in existence: the integral calculus, the calculus of variations, etc., and we may also count the much discussed 'principles of action' of mechanics

(Hamilton's Principle). But all these attempts are really converse in direction; they are concerned with building forms out of magnitudes. What we require is a determined reversal of this process. I myself am unfortunately not sufficiently versed in logic to be able to say whether it already possesses the necessary armament.

Mathematics so far has dealt only with magnitudes, and with the relation of two or more magnitudes to one another: the function. Classical physics, working with this mathematics, attempts to reduce the Gestalts of nature to functions. On the contrary, the mathematics which we foresee will place the concept of form at the head: that is to say a totality, which determines all its parts or elements, and conversely, is determined by these. It would be built up as a fourth stage upon analysis, or the theory of functions, in the same way that the latter is built up upon arithmetic and algebra; and the few beginnings of which we have spoken above would be related to it somewhat as the early beginnings of differential calculus in the time of Galileo and Kepler are related to modern calculus; I mean such things as the problem of tangents and the calculation of surface area and cubical content by exhaustion. A programme of this kind may appear fantastic for the moment; the future will show where the truth lies, whether with those who warn us against

adventurous journeys into the unknown from the secure harbour of what has already been attained, or those who, like Friedmann, dare to point the way into untravelled territory.

Let us assume for the present the possibility of such a new stage of mathematical thought, and ask ourselves how the problem of biology would then stand in the light of it. Our wonder has often been expressed concerning the 'pre-stabilised harmony' which exists, and always has existed, between the laws of inorganic nature and the conceptual system of mathematical physics, which has been developed on the basis of the calculus; we will not here enter into the question of its origin, but only register the fact as generally known. We might, therefore, perhaps expect that the 'mathematics of form' would stand in a similar pre-stabilised harmony to the world of organic forms; we must, of course, guard against thinking only of geometrical form. And now we will proceed to formulate a very bold hypothesis.

There cannot be any doubt that a form must contain more elements, the more complicated it is; the exact definition of 'complicated' would, of course, be a necessary preliminary to the new mathematics. If now organic forms possess the power of assimilation and self-regulation – and these are certainly two of their most important powers – they must obviously possess a very high

degree of complication, hence a lower limit to this complication may exist, below which such forms are not possible. *The Gestalt mathematics of which we are speaking must now be able to show that this lower limit of all organic forms is identical with the upper limit of chemistry; that is to say, there must be a kind of 'critical region' in which, when the new mathematics is applied to the real world, the transition between the more general Gestalt mathematics and the special case of mathematics of magnitude takes place.* If this could be demonstrated, we should really understand the existence of the realm of living things, without bad vitalistic reasoning, but as a consequence of a logic immanent in things themselves; and again, there would be a clear division between the realm of the living and that of dead matter.

Ordinary biological mechanism is always open to the objection that it would not be the slightest use if we should attain its ultimate goal, and reduce life to physico-chemical laws. On the contrary, then only would it stand face to face with its most essential problem: it would have to make us understand why the enormous gap between living and dead, which exists without any doubt, should be present in spite of the fundamental unity of law; a unity self-evident from our point of view, but in no way leading to clearer understanding. Most mechanists have not thought about this problem, while the vitalists

have realised its existence but have mistakenly supposed themselves to have solved it by inserting their 'entelechy' or what not into the gap. *The essence of the problem is to find means to understand the great gap between life and death, in spite of the identity of substance.* A Gestalt theory of the kind of which we are postulating could justify itself in no better way than by solving this problem, and demonstrating the existence of a natural frontier which appears of necessity at a quite definite and critical degree of complication.

We may shortly remark in passing that the problem of the origin of species will probably find its place in the same connection. Biology to-day is agreed that only what are called mutations, that is considerable changes in the germ plasm, and mainly in the nuclei of the germ cells, supply the material for a transformation of species, whether along the road of natural selection, or any other. Controversy centres round the question whether these mutations themselves are mere chance changes, or changes directed by means of the environment towards the goal of adaptation (Darwinism, Lamarckism and Psycholamarckism). However strange it may sound, *it appears to me not impossible that ultimately, Darwinian 'chance' will be found to be identical with psycholamarckian 'purposiveness,'* for Darwin's chance means no more than 'fluctuation,' which in the case of a

form of sufficiently complicated structure (here perhaps a chromomere in the nucleus) might result in a kind of upsetting of the heredity factors and their re-arrangement in a new position of equilibrium. But it is just this fluctuation which is incalculable since it is a unique event which goes back to the fundamental point of all being; and here the plan may possibly be decisive, since, as we have seen, it is spiritual in nature.

A biologist of the old school may perhaps find it rather uncomfortable to meet God so directly at this point. He has had too much of this kind of thing in the past, when divine agency was called in as soon as causal explanation could not be carried any further, and it is natural that he should be afraid of further wild efforts of this kind. We can put his mind at rest. We are not dealing here with a refuge for ignorance. We are introducing into his science, biology, what the physicist, hitherto the biologist's ideal scientist, has already been obliged to admit: that *the contingency of being* (not that of thusness) *is perpetual, and not an affair of a single and initial event.* It is open to the biologist to dispose of the matter by the word 'chance.' But this very fact then permits the religious believer to bring the matter into the category of what cannot be determined by calculation: the free determination by God of the individual event.

In order to avoid all misunderstanding, let us once more emphasise that we are not here pretending to put forward a solution of the problem of life. In the most favourable case, the philosopher can only point out, by bold intuition, the way into the promised land; he does not enter it himself or lead into it. This function can only be performed by the patient and laborious individual investigator who works through the continual interaction of fact and theory. Still less am I attempting to produce a new edition of the 'physicotheological' proof of the existence of God. I have just pointed out that any one who does not believe in a God is at liberty to leave the matter as one of pure chance, which in any case he cannot avoid if he admits the validity of modern physical theory. He can be satisfied by saying that the incalculable elementary acts, which at this point are of decisive importance in biology, are none other than the quanta of action appearing in physics, or something very like them. Also, he does not need to accept Eddington's interpretation of the problem of body and soul, for physics does not demand such acceptance, but merely leaves the way open to it, instead of blocking it as in the past by its assumption of material 'substances.' This solution of Eddington is also naturally only a programme for the present just as is the one sketched above. Psychology – in

the most general sense, including the whole of living nature – must first have worked by this programme in every detail, before we can really speak of a solution.

But for those who hold to a belief in God for other reasons, all that we have said leads to an entirely new possibility of imagining His mode of action in the world. Difficulties which hitherto seemed insuperable, now suddenly vanish, perspectives open up of undreamed breadth, and lead the believer to be deeply thankful to modern physics for the liberation which it has brought about. We must first say a little more on this point.

VII

CAUSALITY AND THE IDEA OF GOD

WE now come to the central point of our whole discussion, the idea of God, which we have touched upon in passing several times, but have intentionally left until now, in order to lay the foundation for its profitable discussion.

History teaches us how classical mechanism led of necessity to the eighteenth century deistic idea of God. In actual fact, if the course of world events is determined by laws and an initial state in Laplace's sense, the creator apparently retains only the function of first determining the laws according to which the great machine is to run, and secondly of building it and winding it up at some particular point of time in the past. It is perfectly clear that a God of this kind is not such as religion requires, and it was therefore a matter of historical necessity that on the one hand deism should develop in atheism, and that on the other hand attempts should be made to reintroduce a living and acting God in place of one of merely historical interest. This endeavour is

certainly not easy to carry out, and we can distinguish in the history of philosophy and theology two main currents. One agrees with Goethe:

> Was wär' ein Gott, der nur von aussen stiesse?
> Im Kreis das All am Finger laufen liesse?
> Ihm ziemt's, die Welt im Inneren zu bewegen,
> Natur in sich, sich in Natur zu hegen . . .[1]

This mode of approach brings us more or less to pantheism, and often passes right over into it; hence it has found little sympathy with clerical theology, since it was feared that a personal God would be lost, and this fear was not unjustified.

Hence the churches therefore generally prefer to take another means by which they hope to avoid the deistic idea of God; proofs were sought that God had not exhibited His creative power once only, namely at the beginning of the world, but has exerted it during the whole course of the world's existence, and still continues to do so.

This interpretation was given to Christ's words of St. John v. 17. The development of life from dead matter, of mind out of body, of human spirituality from animal nature, but also the creation of each new individual human

[1] From 'Gott, Gemüth, und Welt,' *Gedichte*, vol. 2 (Weimar, 1888). A literal translation runs somewhat as follows: 'What sort of a God were He, Who only worked from outside? Who merely allowed the Cosmos to revolve around His finger? It is fitting that He should move the world from within, cherishing Nature within Himself, and being cherished within her.'

being, and innumerable more or less evident 'miracles' of history in general, and the history of 'human salvation' in particular, all these were called upon to witness to the past and present working of God in nature. And this view was described as Christian theism and contrasted, on the one hand with deism, and on the other with pantheism.

A closer examination of this view shows it to be fundamentally hardly different from a kind of multiple deism. Instead of having God perform creation once and for all in the beginning, He is supposed to exercise creation many times, but always in single and quite definite acts and at quite definite times. But this is no easier to reconcile with present day physics than with classical physics and deism. Only one view is compatible with the new physics, a view that takes seriously St. Paul's words 'in Him we live and move and have our being.' This view is, therefore, an approach to pantheism, inasmuch as it does not limit the working of God to individual acts performed upon nature from without, but regards the whole world process, in its entirety and without exception, as resting upon God. This makes creation equivalent to maintenance, and is the *creatio continua* of the old theologians.

It is merely a preconceived idea that this necessarily leads to pantheism. The latter denies

the personality of God, that is to say the doctrine that creation proceeds from a Being fully self-conscious and free to will. But this is an entirely different point, which has nothing to do with the former. It is entirely possible to hold fast to the personality of God, and nevertheless to regard the whole world as immanent in Him; only He must not be allowed to merge into the world. This compromise is known as panentheism. In some form or another it is accepted by most Christian theologians of the present day; only a few who are strongly attached to the purely transcendental God (these are chiefly the 'dia-lecticians') reject altogether every notion of immanence. We shall deal with this school of thought later. Here we can only point out for the present that the whole of Christian theology during the last century actually had no other weapon against naturalism and materialism than to teach that the course of nature is an expression of the will and thought of God.

For present day physics, the contingency of being is distributed quite evenly over the whole course of the world. From this point of view, it is therefore meaningless to regard only an 'initial state' as settled by God, and the whole remaining course as that of a 'clock running down' (Reich-enbach). A physicist, of course, is not of necessity compelled to arrive at a God as creator of the

world. One can be satisfied to say that the world exists. But if we are willing to ask for an answer to the question of a creator, we may safely say that present-day physics renders the deistic notion of God meaningless; only a theistic or pantheistic concept is discussible. The old dogma of *creatio continua* corresponds best of all with our present-day physics.

Here we must make a remark which is not new but can hardly be omitted in view of ideas which still rule in many Christian lay circles. The theologians have almost all been in agreement since the earliest time, not alone among Christians but previously, that God's working upon the world must not be regarded from the human standpoint of time. If a proof were needed that this view is the only one possible, it has been given by the theory of relativity. For according to it, time, like space, literally is just as much a part of the world as a magnetic field is part of a magnet. Where there is no matter there is also no space and no time, and, by the way, there is no obstacle to our regarding time also in the non-euclidian sense, for example as finite and returning upon itself, and in other ways also. It is obvious that on this basis such questions as the famous one, as to what God did before He created the world, are completely nonsensical. Luther's equally famous answer that 'He sat behind a hazel bush

and cut sticks for the askers of useless questions,' thus hits the nail on the head.

God's settlement of the world process is an extratemporal *actus purus*, which we can only imagine by analogy with human mental acts, which in themselves are likewise timeless, although the human being, regarded psychologically, always requires a certain, though very short, time to execute them. Logical deductions, for example, are mental acts of this kind. When a physicist deduces from a number of formulae representing wave motion, conclusions concerning the mode of interaction of these waves, the content of these conclusions is not in any way modified by the fact that he needs a shorter or longer time to think out the problem, according to his mathematical aptitude. On the contrary, these conclusions are contained, timelessly as it were, in the single formulae. Likewise, the time of thought has nothing to do with the time represented in the formulae by the letter *t*, that is to say, the time in which the wave processes take place. We can imagine the mental acts by which the physicist in question calls to mind the formulae, and likewise those by which he draws the conclusion, as completely timeless, without in any way changing anything in the formulae. The relationship of God to the world can only be thought of under the picture of such timeless determination, though

here naturally there exists the essential difference that God's settlement of the world process actually becomes a reality through this determination, whereas a formula thought of by a human being, remains a thought and nothing more.

When we make this quite clear to ourselves we see that *it makes creation anything but a beginning in time.* The time in which the world process proceeds, in so far as it is a part of objective order and not merely a subjective form of human perception, is itself a part of the content of God's settlement of the world. Whether He decided it to be finite or infinite or returning upon itself or otherwise is quite a subsidiary question. God also created the world, that is, it exists only by His will and according to His plan, even if it has existed from infinite time. Why should God, who Himself is the Infinite, not also be able to bring into existence a world infinite in time? Who denies this has not conceived the meaning of 'His thoughts are not our thoughts.'

If we bear firmly in mind that creation and maintenance are entirely one and the same, we shall be once and for all safeguarded against every new attempt to make again the world something existing independently, that once sprang from God like Athene from the head of Zeus, and now carries on its existence in relative independence, and hence might now and then cause God to

interfere with the course of events. When a great artist composes a work of art, say Beethoven a symphony, it is meaningless to say that he has interfered here and there with his own work. For while it is being created it exists only in him and through him. We must hold firmly to this fundamental principle in all circumstances, even when we speak, in the Christian sense, of the contrast between God and the world, that is, the sum of individual wills. *This contrast lies in the realm of values, not that of existence.*

It is a merit of the Christian Church which cannot be too highly estimated, that in the first centuries, in face of all difficulties inevitably presented by the problem of theodicy, it held firmly and unconditionally both to monism in creation and dualism (good and evil) in the realm of value. On the one hand, it rejected every attempt to abandon the former, and to postulate the initial co-existence of two principles (God and matter, *Pleroma* and *Kenoma*), and thus do metaphysical justice to ethical dualism. On the other hand, it rejected with equal assurance and firmness every variety of ethical dualism whenever this view appeared, as most recently in liberal Protestantism, in favour of monism in creation. The Church of both confessions exhibited here a perfectly true instinct, for this irremovable tension actually has its roots in the nature of the idea of

God, which cannot be otherwise grasped than as loaded with such apparently irreconcilable contradiction.

For a God such as every higher religion needs is no God if He is not omnipotent, but then He alone and no other being near Him is there from the beginning of things. On the other hand, the God of all higher religions is likewise no God if He is not the absolutely Holy, Who always and everywhere judges and values; that is to say, settles what ought to be, but is not. The latter God stands in sharp contrast to the world, while the former contains the world within Himself entirely. It is not the slightest use to attempt to talk our way around this difficulty. Christianity cannot do better than to point it out as clearly and undisguisedly as possible and then take the greatest possible care that neither side trespasses upon the territory of the other.

Such trespassing takes place when evolutionary Liberalism waters down the nature of sin to mere imperfection, or a lower level; and conversely, when dogmatically prejudiced orthodoxy attempts again and again to identify the contrast between God and evil in some way or another with a contrast between Him and creation. I am perfectly aware that just this has been expressly rejected on innumerable occasions in clerical theology, but this has in no way prevented people thinking of

the 'natural' as in some way necessarily linked with evil (mainly in connection with St. Paul's words concerning the 'flesh'). In particular, this has given rise, in Christian circles of both confessions, to a confusion between sin and sex, since in the latter mankind most clearly demonstrates its connection with nature; although theology of to-day officially repudiates this point of view in the most decisive manner.

From this point it is only a step to a complete separation between God and the world. The most influential direction of evangelical theology of the present day, that of Barth-Gogarten, has avoided this error no better than almost all 'positive' theologies of the past; that is to say, theologies stressing the doctrine of redemption as their central position. According to it, 'identification,' that is to say none other than monism in creation, is not only the cardinal error of all theology, but actually identical with original sin itself, since it makes God the object of human thought, of the world, and thus makes the latter, as it were, master over him. Barth repeatedly stresses the fact that for this reason every attempt at a theistic world view is self-contradictory. For him, God is simply and only the 'quite other.' He does not consider that he is thus, so to speak, throwing creation at God's feet, that he himself, Barth that is to say, is actually daring to deny to

God the right to reveal Himself to His creatures through His own creation, and much else. All other ideas have been crushed by the simply unbridgeable contrast between Him and ourselves. Or otherwise expressed: the first article has been put out of force in favour of the second, which is made supreme.

I am well aware that disciples of this school object strongly to this reproach. They point out that they and Barth make the omnipotence of God their central doctrine. But this concept of omnipotence which they maintain is in truth not the pure idea of omnipotence, for this necessarily also includes revelation in nature and history, and hence the immanence of God. On the contrary, it is rather a concept of omnipotence which has been decidedly modified by the second article or rather its fundamental assumption, namely the doctrine of sin, and hence knows only transcendental Deity. This has taken us far away from physics and right into the midst of the theological polemics of the present day, but it belongs to our theme, since it is just in this direction that we wish to pursue the conclusions to be derived from modern physics. I must now add a second remark, which likewise will be less welcome in certain clerical Christian circles than what has been said concerning the supersession of mechanism in present-day physics. Honesty

makes it necessary to say here what must be said.

It is a complete error to attempt now to uphold belief in miracle, in the ordinary sense of the word, by basing it upon the purely statistical character of natural laws. Let us take the example we have cited from Perrin of the tile. When this falls off a roof, there is a possibility every $10^{10^{10}}$ years that chance unevenness in the distribution of molecular pressure may give it a considerable impulse sideways, and thus, for example, divert it from the head of a passer-by which it would otherwise have struck, if its fall had taken place according to the normal (that is to say average) law of falling bodies. But if the argument is put forward in theological quarters that the possibility of a miracle is thus proved the result would only be to damage theology's own case. For in the first place as we have seen, the probability is so small that it may be regarded as practically identical with impossibility. If one such tile had fallen every second since the beginning of the history of humanity, no noticeable fraction of the time would have passed which, according to Perrin, would be necessary for the case to occur. And secondly, even if such an immeasurably small possibility should actually once be realised, there would be again a second, almost equally great, improbability that it should happen just at the very moment when the passer-by,

who was to be 'providentially' protected, was under that particular roof.

Similar considerations apply, for example, to the walking of Peter on the water, which is naturally also imaginable as a result of unequal molecular pressure, but even less probable, and other miracles. Hence the theological world cannot be too strongly warned against attempting to make capital in this way out of the new discoveries. Regarded as rules governing events in macroscopic dimensions, the laws of nature are not less invariable in practice for us, because they have been recognised theoretically as based upon statistics, a statistics which in sub-microscopic dimensions depends either upon pure chance or free decision.

Nevertheless, our new knowledge does not by any means appear to have no bearing on the theological problem of miracle. For it teaches us, quite without possibility of misunderstanding, a fact that wise investigators of this question have always stressed, namely that the whole question is not in any way *quaestio juris*, but rather *quaestio facti*. For those who hold to strict causality in physics also recognise quite clearly that an omnipotent God can perform miracles. Why should not a God who settles the laws of nature not be able, if he so desires, to put them out of force? The question whether God can perform miracles

is meaningless in itself, it contradicts its subject, namely the omnipotence of God. The only question is whether God has actually performed them, or whether we have reason for supposing that He will, and not can, perform them. But this question is one concerning only history, or biblical criticism. I have no intention of raising it here, for in the first place I should need to write a second book about it, and secondly I should lay myself open to the reproach of trespassing upon extraneous territory. I can only beg all those who seriously think about such problems to examine the question entirely without prejudice from the historical point of view, which, of course, must not begin by saying that miracles have not occurred because they are impossible. But doubts concerning the credibility, or at least the correct interpretation of the miracle stories of the Bible will perhaps also occur to anyone who simply considers, quite soberly, the question as to what really happened.

Finally, there is one further point to be mentioned which has several times been raised in my debates concerning the present subject. One might be inclined to think that the gain derived by Christian theism from the new physics, is set off by an equally considerable loss, namely the reduction of the whole world, in the last instance, to chance. Classical physics showed us after all,

a world which was at least a cosmos of 'great eternal iron laws,' a cosmos perhaps cold and dead, but one also great and awe-inspiring, to which Kant's saying concerning the starry heavens was applicable. The new physics now hands this whole cosmos over to pure chance, with its statistical laws. This might seem to be fundamentally less in keeping with our belief in an omnipotent, and above all an eternally wise God, than the old point of view.

This objection is certainly not easy to dispose of. One might say that all arguments once adduced from the Christian side against the Darwinian theory as a doctrine of chance, must now be put forward to oppose this view of the fundamentals of all material being. But when we look more closely at the matter, the objection is found to depend upon an all too human view of God's activity. It is not our business to prescribe to God how He is to arrange things so that we are able most easily to perceive traces of His working in creation. He has always been greater than all human thought concerning Him.

Who will deny that He is, in living nature also, the *Deus absconditus*? We need only think of the enormous waste of germ cells, of the enormous over-production of offspring, which is compensated for by an equally enormous rate of destruction, in order to see that in this respect also, His

ways are not our ways. If, then, it has pleased Him to bring into existence this apparent cosmos of natural laws by means of the pure logic of statistics (arithmetic), or in other words to show that it lies in the nature of pure reason to derive the apparent order of the macroscopic world from a sub-microscopic disorder, who shall say that such a procedure is unworthy of Him? The new physics demonstrates strikingly that all our discovery of natural law, as we have said above, is simply following in His tracks. To put it quite crudely and plainly: to work in physics consists fundamentally in nothing else than counting up the elementary actions of God. Notice that we are counting after the event; He determines each single one of them; we cannot influence them in any way and not foresee a single one. We can only determine afterwards what the average total result is, and then expect to find again this result elsewhere with more or less probability.

In the older physics, in spite of all nominalist protests, the impression very easily gains ground again and again, that the laws of nature compel, as it were, the course of events in a real sense. For when the state of affairs is given at the moment t, the state at the moment $t+dt$ is supposed to arise of necessity, according to fixed natural laws; which thus prove to be, as it were, productively active powers, at least in respect of

all the detail of what follows. Only the initial conditions and the laws necessarily have another origin. This mistaken idea now disappears of itself, and we need go to no great philosophical trouble to get rid of it. In the literal sense, not a single quantum of action exists in the world which does not proceed directly and immediately from God. No natural law, not even a statistical one, compels its existence. Such a notion is just as meaningless as if we were to imagine that the statistics of railway accidents or marriages made one year compel those accidents or marriages taking place the next year, to occur. I think that the enormous liberation which this insight brings to religious thought makes it worth while to accept the apparent chance which it requires. For in truth, believers have always hitherto regarded chance as God's direct will (Matthew x. 29). This now becomes an evident fact, for the chance in the final elementary actions of existence is nothing other than the completely free decision by God.

We have now arrived at the point of contact between the problem of God's existence and the last problem which remains for us to deal with, namely that of human freedom. We must devote a few words to this.

VIII

THE PROBLEM OF HUMAN FREEDOM

NO one possessing a distant acquaintance with the limitless literature dealing with this controversy will lightheartedly maintain that the problem has been finally solved. Only dogmatic prejudice can be satisfied to say that determinism has beaten indeterminism, or vice versa. But the most puzzling part of the matter is the fact that both sides lay claim to presenting the sole tenable basis for ethics. Determinism maintains that only a faith in fixed rules, governing human action also, can render ethical principles secure, since only thus can we expect a person to act in a certain way in certain circumstances. It is maintained that all education is absurd if it is not based upon the postulate that the principles inculcated in the pupil later become active as motives, that is to say, can be counted upon as causes influencing the decision, and, in given circumstances, as determining it. On the other hand, indeterminism denies that it is possible to talk of moral responsibility, if what I shall do is decided causally beforehand. So

far, neither of the two parties has been able to convince the other.

Before we enter upon the question as to how this problem is related to the new point of view in physics, it would be well for us to recollect the previous history of the problem. In the form of the question: natural law or free will? it is, of course, of more recent date, but in another form it is already very old, namely as the question whether God's omnipotence alone is operative in human action, or whether this action is in any degree independent. In the history of the churches we have, for example, such discussions as the controversy between monergism and synergism in the doctrine of justification, or the controversy concerning the idea of pre-destination. It is not, however, difficult to recognise that the latter and older formulation of the problem by no means coincides with the former more modern one. This relates to the thusness contingency of the world, whereas the older theological form of the question relates to the contingency of being. We shall return to this point shortly.

The first matter to be settled, therefore, is the nature of the question which can be reasonably asked. For in controversial matters of this kind, which appear to be insoluble, there is always a very strong suspicion that the question has been

wrongly put. In order to deal with this question of formulation, we must first realise clearly that the usual analogy, generally applied in the deterministic sense, between the motives of the will and physical forces, is a purely superficial picture, from which no conclusions can be drawn. When we speak of the resultants of motives in this metaphorical sense, we should be quite clearly aware that we are applying a physical concept to something which is quite different in nature, namely a spiritual entity. It would be much more correct to describe the forces of physics, conversely, as anthropomorphic projections of motive into non-living nature – 'the last remnants of fetichism in physics,' according to Tylor – than to hope to grasp the interaction of motives by means of a picture based on forces. The commonest argument of popular determinism, namely that an action results from the various motives concerned in the same way as motion occurs as a result of the various physical forces acting, is, conversely, an 'anthropomorphic short circuit.'

Recognising this error, the philosophers, in so far as they have learned to think critically, generally base determinism on quite other reasoning. They appeal to the general category of causality, that is, a (supposed) law of thought, according to which man is compelled by the organisation of his thinking powers to enquire, always and

everywhere, after a cause or causes, and hence in the particular case of the actions of other human beings; in this case the causes demanded are obviously the motives. For – so the reasoning goes – if anyone should answer my question: why are you doing that? by the answer: just because I want to, I should simply proceed to ask: why do you want to do that? And this means no more than that I am seeking the motives leading to this act of will. According to this view determinism would be an epistemological postulate but not an ontological or metaphysical doctrine.

Against this view we have to set the whole post-Kantian development of epistemology, and in particular everything which we considered above concerning the dissolution of Kantian apriorism under the influence of modern physics. The transition from the human demand for causality, which we will assume to exist for the present, to an ontological assertion that everything is determined, is precisely the same thing as for example the transition from our perception of space to the assertion of the unique validity of euclidian geometry, or Kant's quite naïve transition from the ordinary concept of substance to the 'law of conservation of mass': it is a μετάβασις εἰς ἄλλο γένος.

In the most favourable case, it is proved that we human beings cannot imagine space other than euclidian, that we persist in attempting to

imagine physical events in mechanistic terms (substances in which phenomena are produced by forces), and that we in the same sense always enquire after causes. But this is very far indeed from being a proof that the actual ordering of the world which appears to us under the aspect of space and time, is actually euclidian and galilean, or that the world consists of substances, to which and through which, secondarily, something happens. In the same way there is equally little proof that the category of causality is more than a human idea of provisional utility, and that this might not, just as easily as the former, be superseded in the progress of thought.

Kant saw quite correctly that all these forms of perception and thought are settled for us *a priori* and that our sense perception, as he expresses himself, and our thinking concerning reality make use in the first place of these forms, but he was wrong in supposing that we are simply tied to them inevitably. He did not perceive that pure thought is able to carry us beyond them, a fact sufficiently shown by the simple existence of noneuclidian geometry, even if the latter had not afterwards been shown to be a form much better adapted to the objective nature of things. Our conclusion is, therefore, that determinism cannot be founded upon these epistemological considerations.

The assertion that every human act of will must, like everything else in the world, have a cause or causes, is and remains an ontological assertion, which relates to the content of the world, and as such can only be proven or refuted by taking into account everything actually known to us in this connection concerning the world. It is not our business, as the apriorists would have it, to measure facts by means of our mental constructions, but conversely, to adapt the latter to the former. Now we have seen above what is left of our perception of space and time and of our concepts of substance and causality, when we take our present-day knowledge of the physical world for a basis. We have seen that it is at any rate something quite different from what Kant, basing himself upon Newtonian mechanics, believed to be the truth. Anyone who compares without prejudice the *Critique of Pure Reason* with the system of present-day physics, without feeling this with irresistible conviction, is beyond my aid.

But when we are clear on this point, we are equipped to formulate the question as it can alone be formulated, if it is an ontological and not an epistemological question. We can obviously do no more than ask: *taking the whole that we know concerning nature, including man and his mental activity, are we compelled to draw the conclusion that the actions of human beings can, in principle, be calculated in the*

same way as the processes of non-living nature, that is to say of physics and chemistry? In my opinion, to ask this question is to answer it in the negative. For in the first place we are dealing in two cases with entirely different things: in the case of physical processes, as we saw above, with the mathematical form of certain elementary actions which in themselves are indifferent to physics, and the nature of which we regard, for other (non-physical) reasons, as determined by spiritual agencies. On the other hand, in the case of the human will we are, without any doubt, dealing directly with these spiritual processes. This fact alone at once excludes a simple prolongation of physical law into the realm of acts of will. But on the other hand, we have seen that this physical law itself is only a matter of statistical rules. Its apparently limitless certainty in the realm of macroscopic dimensions depends only upon the limitless numbers of elementary actions which are counted.

Before we can really approach the question of the freedom or otherwise of the will, we must first know how an act of will is really related to this totality of elementary actions which we count up in physics. Obviously, a final pronouncement upon this point can only be made when the psychophysical problem has really been solved, which at present, as we have seen, is very far from

being the case. We are thus thrown back upon merely tentative suppositions and rough calculations. Hence what I am about to say is only to be regarded as a quite non-committal and temporary construction, which may perhaps shed some light over a short distance of our path into the future, or on the other hand, may merely lead us astray. Nevertheless, we must make the attempt, since it is possible to be fairly positive even to-day on a number of points which may be of importance in the future.

In the first place, when we formulate the question as we have just done, namely whether acts of will are calculable by physical methods, we are already stating it wrongly, for in all probability it is not a matter of 'either – or,' but rather of 'both – and also.' It would be more correct to enquire how far acts of will are calculable, and how far they contain an incalculable element. There can be no doubt that those acts which we describe as the acts of will of animals or man (possibly also plants) are, to use the neutral language of parallelism, accompanied by very complicated bodily processes taking place in the nervous system and elsewhere. Hence by analogy with what we have said above we may suppose that *the calculability will become less in the same degree as the complication becomes greater*. For these reasons we might perhaps predict with a very high degree

of probability what a bacillus or an amoeba will do in the next instant, if we are in possession of all the data, with less probability the same concerning a bee or a fish, with still less concerning a dog or an elephant, not to mention a chimpanzee, and with least of all (so far as we know at present) concerning a human being. Indeed I should like to venture upon the hypothesis that we have here to do with a new critical limit, a definite degree of complication, at which again a kind of leap takes place, similar to that existing at the boundary between matter and life.

But this new limit must be concerned with something else than the other limit. In the latter, on the boundary between matter and life, we were dealing with excessive complication of chemical structure, resulting in chemical structures becoming unstable. But it is this very peculiarity that enables them to become the carriers of life, the characteristic of which is a 'lability' not otherwise known to us in chemistry. The matter composing living organism is distinguished in the first place from non-living matter by the fact that it only continues to exist when in a state of continual interaction with the environment (apart from states of apparent death, which need special discussion). There cannot be any doubt that this interaction depends upon the existence of excessively intricate

complexes of matter, which continually exceed 'the upper limit of chemistry.' Only by this means obviously is it rendered capable of that minutely accurate 'adaptation' to the environment, which beginning with the most primitive processes of assimilation, finally leads to the nervous system with highly developed sense organs on the one hand and co-ordinated muscles on the other.

This series of higher and higher organic forms, therefore, differs from the corresponding series of inorganic forms (electrons, protons, atoms, molecules) in that we have not any longer a form spatially limited and self-sufficing (apart from certain general conditions of existence) but rather the setting up of a Gestalt[1] which includes the living being together with its environment.

From this point of view, the new critical limit is as follows: the human being comes into existence when this relationship to the environment extends, potentially at least, to the whole world; that is to say, in mathematical language, at the limit $n = \infty$ for the number of environmental elements concerned. The animal knows only his own world (Uexküll), the human being, even the most primitive, knows something of *the* world. This

[1] The German word 'Gestalt' has now been adopted into English psychology, and here as everywhere it refers not only to spatial form but to a whole having unity in the more general sense. (Trans.)

again is not a new observation, but has been stated in this or other form by philosophers on innumerable occasions. We are only putting all this forward at this point in order thereby to set our problem of freedom in a true light. Here as in the problem of life, we are not dealing with the bitterly controversial question whether a continuous transition exists between the higher and the lower form (here human being and animal), but how we are to render comprehensible to ourselves the leap which undoubtedly exists.

We do not succeed in this either by following the bigoted Monists in levelling away as far as possible the difference between man and animal, nor by adopting the views of their opponents, mostly to be found in the Christian camp, and emphasising as sharply as possible the 'completely unbridgeable gulf,' but only by attempting to construct a system of logically connected concepts of sufficient breadth to enable the necessary appearance of this second leap forward in the world to be rendered comprehensible. If it lies in the nature of organic form that its development to a certain point of complication leads to a natural conclusion beyond which a further development on the same line is impossible, we have then understood why, to what extent man is more than an animal; and at the same time we have maintained continuity.

The foregoing considerations lead to the conclusion that *the problem of freedom is separated from the problem of physical law, not by one step, but by two.* The curve of world forms possesses, so to speak, not one bend or leap but two. It is hence pure dogmatism to extrapolate from the first and lowest portion of this curve over to the third, as all determinism does. Our only guide at present can be pure empiricism, and this tells us that in actual fact acts of will are predictable to a certain extent, even in the case of human beings. Given the hereditary constitution and environment of a human being, it is probable that, if all the necessary data were known, a great deal, and perhaps nearly everything, about him could be predicted. If any proof were needed of this, recent investigations of heredity, particularly in the case of identical twins, have afforded it.

However, prediction based upon pure empiricism is naturally loaded with a certain coefficient of uncertainty, and it is the task of investigation to make clear to what extent such empirical uncertainty depends upon simple practical ignorance of the necessary data, and to what extent upon fundamental 'fluctuations.' In physics, as we have seen, this problem has been solved in principle; we are now quite clear that what are commonly called 'experimental errors' depend upon a quite different kind of uncertainty from

that concerned in subatomic fluctuations. The former are purely technical and practical in nature, and depend upon the fact that our apparatus is not constructed with sufficient accuracy and that our sense organs do not perceive with sufficient accuracy. The subatomic fluctuations, on the other hand, are fundamental in nature, and depend upon the fact that the absolutely exact statement of position, impulse, and so on, is impossible, since the world is not constructed in the manner assumed by such a demand. In physics, therefore, the problem may be regarded as solved in principle.

But in the case of biology, and still more in that of human psychology, it is obviously infinitely more complicated. In the first of these cases we are dealing with the organic Gestalt, a structure labile with respect to the environment; that is to say, with the total system, animal plus environment. And in the case of man we cross a further border-line, to the limitless environment. No one can say for the present how the matter of calculability will turn out. It is first necessary to solve the problem of life and that of mind and body, which is most closely connected with it; and further, the problem of development of man from animal would also need to be solved. There can, of course, be no question of any of this having yet been accomplished.

However, we can still say something more concerning this problem if we once more recollect the first of the two objections brought above against the application of simple physical causality to the will. Physics treats, as we have said above, only of the mathematical form of elementary actions, the nature of which is left undetermined, but is presumably (according to Eddington) spiritual in nature. Hence voluntary actions belong to this fundamental basis, the mathematical form only of which is grasped by physics. From this follows a very important conclusion, the neglect of which would in any case wreck the whole problem: *if voluntary actions are contingent in any respect* (*that is to say not calculable and logically determined*), *their contingency is not that of thusness but of being. If the human will is free in any respect, it is free as are the elementary actions of the whole of creation. Hence the deterministic argument again depends upon falsely equating natural calculability with effective and real causation.* The assumption is that the state of affairs at the present moment compels that existing at the next moment to come into existence. We have already said all that is necessary to refute this view.

But what we then said may perhaps point the way to where a solution of this much discussed problem is to be found. It is obvious that physics, regarded in the light just mentioned, has no

other subject matter than this order of elementary actions in space and time, or more correctly, in that abstract four-dimensional scheme of order which we experience as perception in space and time. This order forms, so to speak, the lowest stage of all world order whatsoever. What is called physical law can be deduced from it by means of pure arithmetic. But nature shows us quite clearly that this arithmetic of chance is not all, but that beyond it structures exist, the organisms namely, exhibiting order on a higher level, namely the hierarchical order of 'wholes' discussed above. He who will understand the world must needs not only understand this purely arithmetical order, that is to say, learn physics, but must also, as we have already said, attempt to follow God in constructing the Gestalts in question, that is to say, he must work at biology.

In this second stage of order, that which exists is not only ordered according to the four co-ordinates, x, y, z, and t, but also according to a point of view of quite another kind. But for the present we are unable to see in what relation that which we call the individual will of a single creature stands to the universal will from which all single elementary actions proceed. The problem of mind and body is none other than this, seen as it were from the other side. As we have seen above, it appears to-day to be soluble

in principle, since all substance according to present-day physics can be regarded as simple form, and hence no obstacle exists to taking the spiritual as substratum of this form. Nevertheless, the question remains how, in a psychological connection, we are then to imagine the relationship between elementary actions and the 'individual minds or souls' belonging to whole complexes of the elements. Here everything remains to be done, we have hardly the first beginnings of a true solution in our possession. In this respect biology and general psychology are in about the same position as was physics in Galileo's time.

The most obscure problem of all is how a human being is to be imagined as coming by his self-consciousness. One thing only is certain, namely that it is not pure chance that the only creature in the world, that at least imagines himself to possess a free will, is also the only one which has developed causal natural science. *Obviously, the sense of freedom and the category of causality are correlated. Man seeks the causes which he does not find in himself, outside himself. The animal neither seeks them within nor without.* From this point of view it is quite clear that determinism's supposed refutation of the freedom of the will is pure dogmatism. For the reason that we have stated, it is like a snake swallowing its own tail.

In some way or another, the freedom of the human will is connected with the transition to an infinite environment, and both of these are in some way connected with the fact that only man possesses religion, ethics, art, science, etc.; or in more general terms, man is the only creature that builds a third new realm of being, that of values or culture. The fundamental concept of physics is that of magnitude, of biology the whole or form, that of the moral sciences value. Magnitudes are counted, forms are constructed, values are experienced and created. In the latter, man takes a direct share in divine creation, which, in him and through him, continues to create also at the present day, that is to say through a conscious individual. For actually art and science, industry and technology, law, morality, and so on are the clearest witnesses to the fact that creation continues, and is perpetually producing something new and never previously existing. Matter, plants, and animals are, as it were, closed chapters in the history of creation. But in mankind creation is continuing up to this day.

But here again one thing must not be forgotten : we have used expressions taken over from the human creative production, which always takes place under the form of time. But creation in the metaphysical sense here intended is an act beyond time, and hence we must not take it literally when

we say that it continues to-day in mankind; this is only meant in a metaphorical sense. It would be more correct to say that the whole of human cultural activity is a part of it. This creative activity in some way includes also the problem of human freedom, for who could be more keenly sensitive to this fact than the creative artist himself? We must, therefore, translate the problem, as it were, into the language of Einstein and Minkowski if we are to see it correctly. The freedom under consideration does not consist in the absence of any cause in time, for that would be thusness contingency, but in participation in the timeless determination of being. That is the kernel which is found also in Kant's doctrine of 'intelligible and empirical' character. But Kant's aversion to metaphysics prevented him from stating this idea in plain language, and his mistaken belief in inevitable empirical causality led him to mistakenly requiring the 'empirical character' to be taken as absolutely determined.

From the point of view which we are here developing, an empirically determined character is not present, but only a calculability within certain limits which remain to be determined, whether on the basis of physical statistics or biological construction of wholes. In so far as human actions are able to find a place within these two sets of logical connections, they are

'conditioned,' that is to say predictable. On the other hand, in so far as they contain a unique and new element, and that is certainly the case for example with all true cultural achievements, since no one has been able to exhibit logically the derivation of values from biological data, in so far are they contingent, which means that they have sprung directly from the same determination from which all elementary actions of the material world and all forms of biology have also sprung. It is not the beginning in time which is the essential feature, but solely this uniqueness, which is synonymous with incalculability.

It follows from what has been said that the problem of freedom thus again flows into the problem of God, for it is a question of how that which is determined by our will of its own motion, forms part of the whole of the totality of world determination. The problem is thus referred back from its modern scientific formulation again to the old theological question as to how the will of the creature is related to the will of the Creator.

But this brings us at once to that problem which alone is worthy of being raised as a religious question, the problem of the conflict between the will of God and the individual wills of his creatures, as well as the conflict of the latter between themselves; the old and time-honoured problem of theodicy, or the world's evil. We see at once

that this is none other than the problem of contingency regarded from the point of view of judgment of value. This problem as such is of extreme antiquity. Apart from the old protagonists of free thought, which have ceased to play any real part, great play is made with it in political agitation by the opponents of Christianity, generally with special reference to the World War and social injustice and hardship, and in this dress it is always sure of success with the masses.

Although a discussion of it carries us beyond the limits of this book, we must not fail to remark that present day physics has performed a service which cannot be too highly estimated by permitting us to limit the discussion to-day to this problem, since all other discussions which in past times were carried on with so much heat have proved to be entirely beside the point, and can no longer be taken seriously by any sensible person. We will further add that all reflection performed by science concerning its own essential problems must also show that, and why, it is incompetent to deal with this matter, however much it may contribute in detail to a more precise formulation of its contents. Physics and biology only teach us, in the first place, what is, and not what ought to be. But the problem of theodicy deals precisely with the question as to how there comes into such a world of being, something which is not

satisfied with this being, but by valuing and judging determines what ought to be. We must be perfectly clear that this is not only true of the ethical sphere, to which theological dogmatism confines it. In the sphere of theoretical knowledge, for example, there is also such a supreme value, namely 'truth,' which is laid by our judgment as an absolute measure upon what simply exists. Psychological being shares error with truth, both are equally real. But only the latter ought to be, and the former ought not. The whole existence of science is a single witness to this theoretical 'categorical imperative.' In this connection we may refer the reader to Eddington's contribution to the Broadcast Symposium *Science and Religion* (London, 1931).

Without going further into this problem here, since it should be treated on its own account, we will only say the following. In the sphere of theoretical knowledge it is easiest to perceive why and how the conflict we are discussing arises with a certain necessity, for here it is evident in itself that the partial view which the single individual is alone able to obtain of the world, must necessarily be, since he is only a part of it, one-sided and at least 'distorted by perspective,' and that, therefore, at least apparent contradictions between these various partial aspects must arise. In fact science may be regarded, as the example of

relativity shows very plainly, as a perpetual attempt to unite these various individual perspective views of the world into an objective set of facts, in which all pictures together exhibit only what is 'invariant' in them, that is to say independent of the observer. The fact that a similar collision must occur within the sphere of will, and there result in a 'conflict of interest,' is therefore probable by analogy and confirmed by observation.

In the same sense we may therefore regard the whole social development of mankind as a process analogous to the development of science, in which what is common or invariant gradually comes to light. But one must naturally remain alive to the fact that analogies of this kind may easily lead to error. Without a doubt all that remains of this is the fact that this conflict between individuals and also against the whole runs right through all living creation, and is far from making its first appearance in man. But since man is the only being whose environment includes the whole universe, the conflict also appears in the form of a conflict with the whole, that is to say God; in other words as conscious sin. But it is a complete mistake to limit evil to this special case, although this is still done by wide circles of Christian theology, as the result of influences ultimately proceeding from Judaism, which originally did not recognise a God operating in

nature, and therefore limited religion to the purely ethical sphere.

The whole problem of theodicy is rather, as we have pointed out above, none other than the problem of world contingency, seen from the point of view of values. Christianity ought under no circumstances to allow this breadth of view, which if need be it can always re-learn from India, to be shut off from it by one-sided ethical argumentation, or even juridical reasoning, such as forms the basis of the Anselm doctrine of Atonement. The evil of the universe is thus as widespread as the universe itself, and hence the second article is just as comprehensive as the first.

This view is not affected by the fact that Christianity, in sharp contrast to Indian thought but in agreement with the fundamental optimism of the Jews, regards creation, not as evil in itself (valueless) but as good (valuable), and cannot, therefore, seek a deliverance, as does the Indian, in simple renunciation of the will to being (Nirvana). While it is true that the individuation of living creatures is the source of all evil, it is also on the other side true, from the Christian point of view, that this individuation, that is the will to live, is likewise the source of all joy in existence and all realisation of value in the world. Christianity, therefore, affirms natural life as such

in all its innumerable forms, for it sees clearly that only in this way could all positive values be realised. The apparently unbridgeable conflict which thus arises is solved by Christianity not theoretically, but practically, by pointing out a way by which the individual will, without sinking back into annihilation, can arrive at harmony with other individual wills, and with the will of the whole. This way is that of self-sacrificing love, which therefore forms the central point of the Christian doctrine of Redemption. In it the apparently impossible is practically realised: 'God reconciling the world unto Himself'; 'For of Him, and through Him, and to Him, are all things.'

EPILOGUE

THE theologian who has followed me so far through the exposition which I have just made, will have been oppressed through the whole argument by a difficult and fundamental question: is not this whole line of thought but a renewal of the old error into which the natural theology of the eighteenth century and the apologetics of the last century fell, inasmuch as on both occasions, though in opposite directions, the attempt was made to bring science and religion on to one and the same plane? What would happen if, in a further ten or twenty years, physics should after all turn repentantly to absolute causality and the differential equation with an unambiguous solution? Can one be certain that this will not happen? And if it should happen, have I not in this work actually played into the hands of mechanism and materialism, the death of which I am over-hastily prophesying? Is it not after all perhaps the truest and safest procedure to draw the line of separation between faith and knowledge as plainly as possible, and to avoid all looking over the boundary from one side or another?

Principiis obsta! I readily concede to my friendly critics – the 'Dialecticians' will go to work with quite other artillery, but they must be fought on another plane – that their objections must be taken very seriously indeed. But anyone acquainted with a few or even a single one of my earlier publications on this subject will know that I myself have again and again raised this same objection to premature, and in my opinion foolish apologetic attempts, that in fact I have declined, more consistently than any theologian, to make capital for Christianity in any form out of scientific results, for the very reasons put forward by my critics. I am also still of the opinion to-day that mechanistic physics by no means implies atheism and materialism as a necessary consequence, and I believe that I made this clear in earlier editions of my book, *The Anatomy of Modern Science*, and this fact is also admitted to-day by the great majority of objective students of the problem.

Even deism is by no means a necessary consequence of classical physics. If I have represented it above as having arisen out of the latter, I was not there giving compelling systematic reasons but only stating a process which, as everyone knows, is an historical fact. But the extremely difficult and abstract investigations which then become necessary to work out a religious world

view alongside such a physics and biology, have after all, as everyone knows who has taken part in the great conflict between faith and knowledge, been a somewhat unfruitful affair, seen from the standpoint of the less philosophically minded layman. It is certainly true, as Hunzinger once emphasised in a somewhat sharp discussion with me concerning the methods of apologetics, that we should not allow our methods of scientific thought to be distorted for the sake of the layman. But it would after all be exceedingly satisfactory if a way could be found which could be followed both by the untaught layman and by the thinker well-trained in all the methods of philosophy. And I believe that such a way is shown us as possible by present-day physics. I say here and have always said everywhere: perhaps! One cannot and should not pronounce dogmatic judgments on some such matters that are still in a completely fluid state, to the effect that things are so and will remain so.

But one should also be careful not to miss what is perhaps the right moment when a prospect appears to open out, by exercising over-great care and reserve. For this reason works such as the present are, as I very well know, loaded with a certain risk. In ten years' time they may just as well appear as the first sign of a new epoch, or, on the contrary, as mistakes which have already

been corrected. In due course this will come about of itself, and I hold in such matters to the wisdom of old Gamaliel (Acts v. 38, 39). It may very well be that in ten years' time, I myself shall be convinced that I should have done better not to write it. If so, I shall not hesitate to admit the fact, just as I do not hesitate to admit to-day that in many matters I was too critical and careful in times gone by. 'The wise are they who ripen to wisdom through error. Those who persist in error are the fools.' No true philosopher should consider it beneath his dignity now and then to reveal undisguisedly one of his own errors. One who cannot endure this, and everywhere sets up a demand for all or nothing, must either abandon himself to complete scepticism, or else to an infallible ecclesiastical authority; I at least know of no other course for him.

The scientist is taught by his science one truth above all others, namely that he lives in a world in which, as Zilsel once happily remarked, 'we may neglect a great deal and yet know something,' or in other words, in which knowledge is possible in spite of many errors, indeed, even by way of these errors; a world, therefore, which is precisely not constructed as Kant maintained in the most erroneous of all his sayings, the statement that mathematics is the only real science in all sciences. The whole of our knowledge of

nature depends upon the 'convergence' of all partial scientific results, and of all partially true hypotheses, theories, laws, and so on; and this convergence only develops in the course of history, that is *a posteriori* and can by no manner of means be deduced *a priori*.

Kant's fundamental requirement that we should recognise, in every science, only that as truly scientific which can be shown to be 'generally and necessarily valid' like mathematics, actually destroys the characteristics of all scientific knowledge at the roots. Kant's requirement stands at the end, and not at the beginning of science, and this statement is more than ever true of philosophy as the science in which all special sciences have their place.

The mistaken idea still retained by us from antiquity, of a science built up deductively upon fundamental actions, to which science physics today is, as we have seen, approaching very closely, is in philosophy quite meaningless, as its whole history goes to show.

We shall never make a single real step forward, if we do not finally introduce here also the inductive method, that is to say, the method of trial and error, of forming hypotheses which are afterwards tested by experience. In this case of course experience does not mean experiment, but the subsequent historical development. A philosophy is

good when it has been able correctly to anticipate this development in some respect, for in this way it shows – and this is its only basis of proof – that in some degree it was on the right track of the inner structural laws of human thought, on the one hand, and on the other, those of the world as the object of knowledge. It is in this sense that I wish my readers to take what I have said in this work. All my statements are provisional hypothetical constructions. No one of the main philosophical positions should come forward with the assertion of its own certainty, but each should only say: it may be thus, or it is perhaps thus. I hope that I have made this clear at a sufficient number of points in the foregoing pages.

It is in this sense, therefore, that I would have the reader take what I have said concerning the relationship between religious questions and present-day scientific knowledge. I am perfectly aware that what I have said goes very far beyond what is called the 'neutrality of science in questions of philosophy.' A theologian who is a well-known specialist in a certain branch of science, and whom I had previously reproached, with infringing this neutrality in one of his anthropological works, in spite of his express recognition of it, and yielding to the temptation of 'apologetics,' wrote to me: 'It appears to me that you and I have exchanged rôles; you are now on the high road

to a physicotheological proof of God's existence, and I am the cautious one.'

While perfectly clear about the danger of this procedure, I am nevertheless taking the risk of it, since I believe myself to possess very strong reasons for saying that it must be so. I actually believe that we are justified to-day in view of the present state of knowledge, in asserting that, although it is not certain, it is easily possible and to some degree probable, that the whole conflict between faith and knowledge will be a matter of only historical interest very soon, and that the struggle between faith and unfaith, which, as Goethe said, will never cease, will as a result be really concentrated in the only realm where it has any meaning, namely that of values, and hence of the problem of theodicy. This position must, I feel, be made clear to-day, to the educated layman at least.

We are compelled to make the attempt, not only by the forward march of bolshevistic scepticism, which has taken a hitherto unheard-of form, but still more by the complete bewilderment on questions of religion into which large sections of the people have fallen. The old authorities have broken down for the most part irrevocably, and among them are the one-time high priests of materialism; but this has by no means resulted in the ecclesiastical authorities regaining their

position. No one to-day really knows what he can, dare, and should believe. Is it not imaginable that God, to whom both I and my critics ascribe the direction of history, may have arranged matters, humanly speaking, quite intentionally in such a way that this surprising and almost entirely unforeseen turn in scientific thought should come about, and that the death sentence of materialism should be pronounced before the bar of history, at the very moment when materialism is setting out, from Russia, to conquer the world by force?

Thirty years ago Christianity was hard pressed and on the defensive, to-day we may say conversely, that it is the aggressor, or would be so if there were more solidarity of will within its ranks. But so much is certain, that Titius was right when he wrote to me recently, 'This is our seed time.'

One further remark. When I myself in the past frequently opposed old-fashioned 'apologetics,' to a point at which I almost became a bogey for its writers, my opposition was mainly based on the fact that their arguments mostly related to what science does not know or knows. It was 'Ignorabimus-apologetics,' a term which I may lay claim to have introduced, and which has now passed into regular use. The authors in question ought to have felt instinctively that no real gain could be made along such lines. For people,

and especially young people, who are those chiefly concerned, will never be won over by pure negation, especially when it takes the form of small-minded carping at great results and bold constructions, as was often enough the case in those days. The enormous success of scientific research, and particularly the advance in biology brought about by the evolution theory and mechanistically inspired experimental methods, was bound rightly to impress the world at the close of last century, and a philosophy which had no other attitude towards all this than a supercilious 'neutrality,' or even systematic niggling criticism was condemned beforehand to be regarded as in the wrong. We may safely describe the fight against the doctrine of evolution as the greatest of all follies of which the church has been guilty in the course of its history; even the struggle against the Copernican system had no such disastrous results, since only small circles of the learned really participated in it, whereas the whole nation was drawn into the fight over evolution. And I am therefore still of the opinion that 'apologetics' of that sort are as useless and injurious as they are impracticable.

Matters are exactly reversed to-day. We again have a great advance in knowledge, which, as then, excites the whole world and would excite it very much more, but for the fact that political

cares overshadow everything. But this new knowledge is now on our side. This time it is we who have youth and the future, the joy in knowledge and the sacred respect for truth, entirely on our side. Modern physics to-day does what astronomy has always done, namely, as Kant says, 'fills the heart with ever renewed awe.' Those who study it receive an impression of the greatness and majesty of God in creation which is quite direct and in no way cultivated or artificial; it is quite modest and simple, and therefore all the grander. This impression arises quite spontaneously from the work of our chief physicists such as Planck, Einstein, Sommerfeld, Eddington and Jeans.

Why in all the world should Christianity refuse now to make use of this revelation which God has given us in His nature? This by no means implies, and must not be allowed to imply, a new edition of the physicotheological proof. But it may also happen again that the theologian, even he engaged in practical work, no longer needs to fear the presence of scientific literature in the hands of his flock, but may really be glad from the bottom of his heart when they study the wonders of creation, since this study will only make his work easier. For matters are now in such a position that anyone who has understood physics even a little is simply proof against the nonsense of materialism.

Such a one will find all the old materialistic arguments, still put forward in proletarian free-thinking circles, to be completely stale doctrine; he will find them ridiculous, and act as a centre of healthy thought for his whole environment. He needs to do no more than pass on to others the deeper truth which he has learned. Truth always works best on its own account, and we need do no more than have it shine as brightly as possible. This fact has been borne in upon the church in the past by its own misfortunes; may it benefit by it to-day.

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